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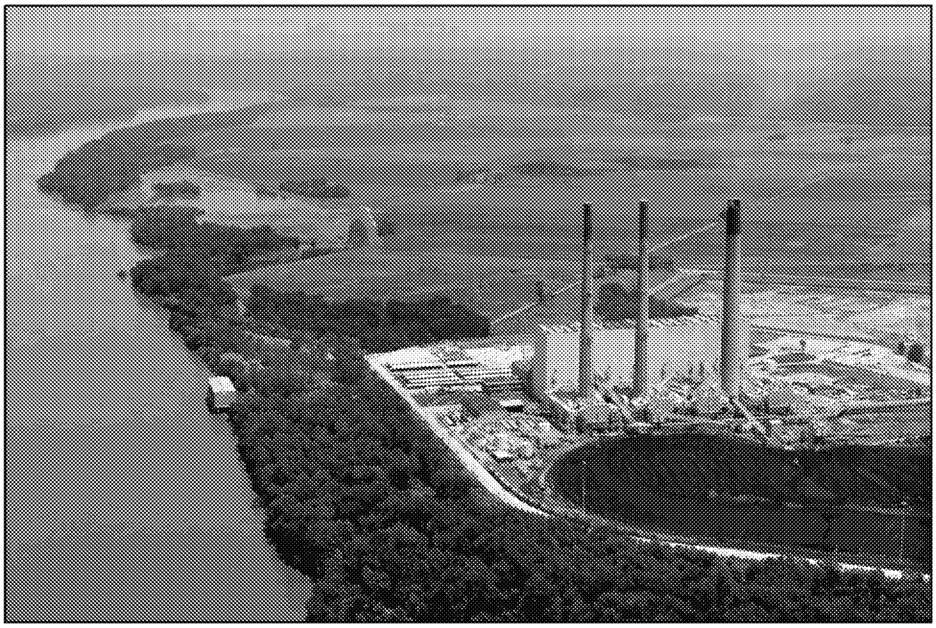
LABADIE ENERGY CENTER
§316(a) FINAL DEMONSTRATION



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APPENDIX A
LABADIE ENERGY CENTER § 316(a) STUDY PLAN AND ADDENDA

LABADIE ENERGY CENTER
316(A) STUDY PLAN

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1. INTRODUCTION

The Labadie Energy Center (LEC) is a steam electric power plant located in Labadie, Missouri on the south bank of the lower Missouri River near River Mile (RM) 57 in Franklin County, 35 miles west of St. Louis, Missouri (Figure 1). The Center has four generating units, each with two circulating water pumps, and a total net capacity of 2,407 megawatts (MW). The LEC utilizes once-through cooling. Cooling water for each unit is withdrawn from the Missouri River via a shoreline intake structure (Figure 2). The resulting heated effluent is discharged (via National Pollution Discharge Elimination System (NPDES) Permit MO-0004812, Outfall 001) to a 1,400-foot-long discharge canal and the adjacent navigation channel of the Missouri River (Figure 2).

Permitting history

The LEC's first unit came online in 1970 and the facility became fully operational in 1973. The LEC was issued an initial NPDES permit in 1975 that specified an effluent temperature limit of 118° F and a schedule for conversion to off-stream cooling by 1981. A 316(a) variance was approved and a new, revised permit issued in 1977 based upon the results of a comprehensive biological and hydrothermal modeling study. The new permit contained an alternate effluent limitation of 10.63 x 10^9 British thermal units (BTU)/hr and removed the prior limit of 118°F and the off-stream conversion requirement.

The LEC applied to renew the 316(a) variance over the next two permit cycles and the renewed variance was granted for the 1982 and 1987 NPDES permits. An application for permit renewal and request for a renewed variance and revised heat rejection limit of 11.16 x 10^9 BTU/hr was submitted along with supporting thermal plume and biological monitoring information in 1992. The new heat rejection limit was based on a revised calculation and represented no additional heat output. The permit was approved in 1994.

An application for the renewal of the LEC NPDES permit and 316(a) variance was submitted in 1998. The permit was not reissued at that time and the department requested a revised renewal application in 2011. The LEC NPDES permit was granted and reissued as the current permit effective August 2015. The current NPDES permit has an interim heat rejection limit of 11.16 x 10^9 BTU/hour with a 10-year compliance schedule to meet the water temperature criteria in the Missouri Water Quality Standards of 90° F and a change in temperature of +/- 5° F. In addition, the LEC is required to reestablish a biological monitoring program to evaluate the potential impacts on aquatic communities.

Missouri River

The Missouri River has changed dramatically over the past century as the result of man's efforts to manage the river for navigation and flood control. Modifications to the river and its floodplain began in the late 1800s simply with removal of snags to permit navigation (NRC 2002). Channel enhancements began in the early 1900s, and damming and flow regulation began in the 1930s. The river modifications culminated in the construction of five US Army Corps of Engineers (USACE) dams on the upper mainstem of the river in the 1950s and 1960s and the completion of the Missouri River Bank Stabilization and Navigation Project in the lower, unimpounded river in 1981. These modifications have reduced or eliminated the river's natural flow regime in which flood pulses in the spring and early summer would create new and productive habitats, cycle organic material and nutrients between the channel and floodplain, replenish water in the floodplain, and serve as cues for spawning of fish and other organisms. As a result, the amount of productive, natural habitat has been greatly reduced. To mitigate the loss of riverine habitat and the natural flow regime, the USACE has instituted the Missouri River Recovery Program.

The LEC is located on the south bank in the channelized reach of the lower Missouri River. The river in this section has also been substantially altered over time by the construction of revetments and dikes and by dredging to maintain a 300-ft wide navigation channel that is at least 9 ft deep. As a result, the channel now is narrower and more uniform than its previous form, with a trapezoidal cross-section resulting in steeper embankments and faster currents. River meanders have been straightened, natural riparian vegetation has been lost, variations in river flows and water temperatures are reduced, periodic overbank flow to the floodplains and its nutrient cycling benefits have been eliminated or reduced, sediment transport is reduced, and natural processes of cut and fill alleviation have been modified.

The modifications and reduction and/or loss of the natural riverine flow regime and habitats has greatly influenced the abundance of native species and affected the overall composition of the fish community. Many native fish species are now rare, uncommon, or decreasing in abundance across part or all of their previous range due to the changing ecosystem and habitat losses during recent decades (NRC 2002). Berry and Young (2001) estimate that approximately 35 native species are declining in abundance while 23 species are increasing. In many river reaches, the abundance of non-native species has become greater than that of native species because of their greater tolerance for the altered temperature regime, flow, turbidity, and habitats. Some of the native species most affected include the pallid sturgeon, plains minnow, sauger, sturgeon chub, and sicklefin chub (NRC 2002).

Historical thermal and biological studies

The LEC conducted a comprehensive biological study and hydrothermal modeling effort as part of the initial NPDES permit application from 1974 to 1975. Hydrothermal modeling delineated the thermal plume under various river flow and temperature scenarios and evaluated the potential for compliance with the Missouri water quality standards outside the mixing zone (Edinger and Buchak 1976). Biological studies included data collection on fish (electrofishing and seining), benthic macroinvertebrates, periphyton, phytoplankton, and zooplankton. Samples for fish, benthic macroinvertebrates, and periphyton were generally collected from both sides of the river upstream of the discharge, just below the discharge, in the discharge canal, and approximately 2 miles below the discharge. Samples for phytoplankton and zooplankton community composition analysis were collected from the intake and discharge areas. The study concluded that the LEC was a site of low potential impact (LPI) for all biotic categories (EEH 1976; Union Electric Company 1976).

Routine biological monitoring of the fish community in the vicinity of the LEC was conducted by Ameren from 1980-1985 and from 1996-2001 (Ameren 2002). Fish were sampled quarterly by electrofishing at five sites in the vicinity of the LEC during the period of each study. Analyses were conducted to compare various metrics, including catch per unit effort (CPUE), diversity/species richness, relative abundance, biomass, and condition factor, between the two sampling periods and with the original 1975-76 study. The studies concluded that the fish community in the vicinity of the LEC was healthy, self-sustaining, and show no adverse impacts from the LEC thermal discharge (Ameren 2002).

In conjunction with the most recent LEC NPDES permit renewal, the Department requested that the United States Fish and Wildlife Service (USFWS) provide fisheries data on the lower Missouri river. The USFWS provided data collected from 2003 to 2011 on a 20-mile segment of the

Missouri river bracketing the LEC. A brief analysis of the data is presented in the 2015 NPDES permit fact sheet. Fish were collected using four gear types – mini-fyke nets, push trawls, otter trawls, and trammel nets. Comparison of the total number of fish, average number of fish per set, and species richness data between stations upstream of the LEC to stations downstream of the LEC showed no significant differences.

The current LEC NPDES permit (MO-0004812) requires that Ameren reestablish a biological monitoring program in accordance with 40 CFR 125 Subpart H to evaluate the potential impact of the thermal discharge. The biological monitoring program must collect data sufficient to support water quality and biological assessments to assure the protection and propagation of a balanced indigenous community (BIC) of fish, shellfish, and macroinvertebrates in the Missouri River in the vicinity of the LEC's thermal discharge.

This study plan outlines the anticipated approach for conducting the required water quality and biological data collection and a biothermal assessment.

2. 316(a) APPROACH OVERVIEW

The 316(a) studies will have three main components:

- Hydrothermal modeling;
- Biological monitoring studies; and
- Biothermal assessment.

A state-of-the-art three-dimensional hydrothermal model will be applied to assist in the delineation of the thermal plume for sampling site selection. The biological monitoring studies will provide the abundance and spatial and temporal distribution information for a retrospective biothermal assessment to evaluate whether the BIC in the Missouri River is being protected. It is anticipated that data collection for the biological monitoring studies will be initiated in early 2017 and continue for a period of 2 years (i.e., through the end of 2018). The remainder of this section provides an overview of the approach for the hydrothermal modeling, biological monitoring studies and the biothermal assessment.

2.1 HYDROTHERMAL MODELING

A state-of-the-art three-dimensional hydrothermal model (Flow 3D, RMA-10, or similar model) will be applied using available bathymetry, field temperature measurements, meteorological data, river flow, and plant operational data. The hydrothermal model application and the selection of sample collection locations will consider and account for the salient features of the river downstream of the LEC discharge such as wing dikes that affect the river flow, habitat type, and distribution of water temperature. The selected hydrothermal model will be used to characterize the LEC's thermal plume over a range of environmental and LEC operational conditions.

The hydrothermal modeling will assist in the design of a biological monitoring program within the area of the lower Missouri River adjacent to the LEC. Information on the thermal plume distribution will be used to delineate thermally exposed and downstream sampling zones.

2.2 BIOLOGICAL MONITORING STUDIES APPROACH

The biological monitoring studies proposed in this study plan will employ a spatially-stratified sampling scheme to account for factors such as habitat type and degree of exposure to the LEC's thermal plume. Samples will be collected within a thermally-exposed zone, an upstream control zone, and a downstream zone. The proposed studies will be conducted using a phased approach that will result in a robust data collection program. First, habitats within the sampling zones delineated as part of the hydrothermal modeling will be mapped and potential sampling locations identified. Second, the biological sample collections will be conducted.

Phase I of the study plan will consist of:

- Habitat characterization/mapping.

Using the delineated sampling zones, areas of available and similar habitats within each zone will be identified for biological sampling using a combination of existing maps, charts, and other available information. A preliminary habitat map showing the basic habitat types within each zone will be prepared. A field survey will be conducted to evaluate the accuracy of the habitat type map by qualitatively assessing various habitat parameters such as, but not limited to, shoreline type, substrate type, water depth, and current velocity.

The combination of hydrothermal modeling to delineate the sampling zones and habitat characterization to identify the habitat types present will provide the basis for selecting the sampling locations for the fish and benthic macroinvertebrate and shellfish collection programs.

Phase II of the study plan will consist of the biological data collection programs:

- Fish; and
- Benthic macroinvertebrates and shellfish.

Fish surveys will be conducted using a variety of sampling gears to collect samples for all substantively present habitat types in each of the sampling zones. The use of multiple sampling methods will serve to avoid gear bias and ensure a more complete inventory of the species present in the subject receiving stream segment. Sample collection for adult and juvenile fish will be conducted monthly during a two-year period. Ichthyoplankton samples in wing-dike and/or L-dike field habitats will be collected biweekly from mid-March through July and monthly during August and September during a two-year period. Ichthyoplankton data from ongoing entrainment sampling at the LEC will be used as an additional source of information to fully characterize the ichthyoplankton community and drift composition.

Benthic macroinvertebrate and shellfish samples will be collected from depositional and rock/gravel habitats quarterly during a two-year period. Samples from depositional habitats will be collected using a standard (9-inch x 9-inch) ponar dredge. Samples from rock/gravel habitats will be collected using Hester-Dendy (H-D) multi-plate samplers.

These biological data collection programs will form the basis for the biothermal assessment.

2.3 BIOTHERMAL ASSESSMENT APPROACH

A biothermal assessment of LEC's thermal discharge will be conducted using a well-established retrospective impact assessment approach. The results of this approach will constitute a line of evidence in an overall impact assessment.

The retrospective assessment will use the results of the two-year biological monitoring program in the vicinity of the LEC, as described in this study plan, and historical data to determine whether there is evidence of prior appreciable harm to the BIC from the LEC thermal discharge. For this evaluation, data characterizing communities in the thermally exposed zone, upstream control, and downstream zones, as well as historical community data, will be carefully analyzed to determine whether there is evidence that LEC's thermal plume has caused appreciable harm to the BIC over the full term of the LEC's operations. The results of the retrospective evaluation will then be compared to phenomena identified by USEPA as evidence of appreciable harm to biological communities. The potential for the LEC's thermal discharge to be the cause of observed changes at the population or community level will be assessed in light of the nature and magnitude of predicted thermal effects and potential interactions with other known stressors.

Depending upon the results of the biological studies, retrospective biothermal assessment, and the need to compile a comprehensive variance request, a predictive biothermal assessment may also be conducted. The predictive biothermal assessment would utilize hydrothermal modeling to estimate exposure temperatures and durations. These would be compared to literature-based thermal tolerance limits for selected species to determine the likelihood and magnitude of biothermal responses elicited by temperatures in LEC's thermal discharge to assess their significance in the context of the regulatory standards and requirements, i.e., the protection and propagation of a Balanced Indigenous Community (BIC).

The significance of biothermal effects will equate to their potential for causing "appreciable harm," according to 40 CFR 125 Subpart H and guidance provided by USEPA's *Draft Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements.*[1]

3. HYDROTHERMAL MODELING

Objective(s)
To characterize the extent of the LEC's thermal plume across and downstream from the discharge under varying combinations of meteorological, river flow, river temperature, and plant operating conditions. Delineation of the thermal plume and the ability to model seasonal thermal discharge and river flow scenarios will assist in the selection of biological sampling locations.

Model Inputs
A state-of-the-art three-dimensional hydrothermal model (Flow 3D, RMA-10, or similar model) suitable for achieving the present study objectives will be selected and adapted to the adjacent Missouri River.

Available shoreline and bathymetric data will be used to apply a computational mesh over the model domain. Bathymetric data will be obtained from United States Army Corps of Engineers (USACOE) surveys conducted in 2001, 2007, 2009, 2013, and 2014. The computational mesh contains discrete points (nodes) where initial condition and depth data are input to the model. In this case, the river model domain will start upstream of LEC's intake and extend several miles downstream. The mesh will include the discharge canal, and mesh spacing will be refined locally in the canal and adjacent receiving waters.

Available United States Geological Survey (USGS) gage data and LEC operational data will be used to identify the historical range of values for model input variables including river flow, river water temperature, plant intake and discharge flows, plant load, and plant discharge temperatures. Understanding the range of values for these input parameters will allow the selection of the most appropriate combinations of variables for model runs to evaluate the across and downstream extent of the thermal plume.

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[1] *U.S. Environmental Protection Agency, Office of Water Enforcement, Permits Division, Industrial Permits Branch (May 1, 1977).*

Field collected water temperature data will be used to validate the hydrothermal model. The available field collected data include discrete plume temperature measurements that were collected on four separate days (one day each in July 2003, August 2003, January 2004, and April 2016).

Biological sampling program support
The selected three-dimensional hydrothermal model will be run under various environmental and operational scenarios to delineate the thermal plume extent/characteristics. This will include a model projection of the downstream and across-river extent of the thermal plume to locate boundaries of potential thermally exposed and downstream sampling zones.

4. BIOLOGICAL MONITORING STUDY PLAN

This study plan is designed to be responsive to the requirements outlined in Section D Schedule of Compliance – Thermal Discharges of the Labadie NPDES permit including:

- Collecting water quality and biological data to demonstrate the protection and propagation of a balanced indigenous community of fish, shellfish, and benthic macroinvertebrates in the Missouri River in the vicinity of the plant's thermal discharge;
- Providing information on the diversity of the aquatic community and the presence of the necessary food chain species;
- Collecting data to demonstrate the non-dominance of pollution-tolerant species;
- Showing the community can sustain itself through cyclic seasonal changes; and
- Upstream and downstream biological reference areas.

4.1 PHASE I

The information and data compiled in this first phase of study will be used to design a sample collection program for fish and benthic macroinvertebrates and shellfish that is stratified by habitat type and degree of exposure to the thermal discharge.

4.1.1 Habitat Survey and Characterization

Objective(s)
To identify dominant habitat types within the thermally exposed, upstream control, and downstream zones so that sample collection may be stratified by habitat type and that all substantially present habitat types are sampled. Habitat type will also dictate, in part, the selection of sampling gear.

Habitat characterization
A preliminary, desktop characterization of the potential habitat types in the thermally exposed, upstream control, and downstream zones will be conducted by reviewing existing sources of data and information on the Missouri River in the vicinity of the LEC. These sources will include, but may not be limited to, bathymetric data, aerial photography, and navigational charts. A preliminary map will be developed to denote the areas of habitat identified.

Habitat survey
A field survey will be conducted to evaluate the accuracy of the preliminary habitat map, fill in any data gaps identified in the initial habitat characterization, and identify potential sampling locations. During the survey, a qualitative evaluation of habitat identifying parameters will be conducted in

areas for which the preliminary habitat identification cannot be clearly confirmed. These parameters may include, but may not be limited to:

- Shoreline type
- Geomorphological features
- Water depth
- Flow
- Substrate type

In addition, any data collection necessary to fill in data gaps identified during the initial habitat characterization will be conducted during the habitat surveys. In particular, if the existing bathymetric data are lacking the necessary detail or spatial coverage for the habitat characterization, new bathymetric surveys may be conducted. New bathymetry surveys may cover the entire anticipated range of the biological survey area or be used to fill in areas with insufficient coverage. If a new survey is needed, a detailed methodology will be developed.

4.2 PHASE II

Based upon the information collected in Phase I, specific sampling sites will be selected to account for differences in habitat type and thermal exposure. This will provide a valid basis for statistical analysis of the data. While the exact sampling sites will be identified subsequent to the thermal plume delineation and habitat characterization, this section presents some anticipated sites and details on the other aspects of the fish and benthic macroinvertebrate surveys.

4.2.1 Fish Surveys

Objective(s)

To document and compare the presence, characteristics, and relative abundance of fish species in thermally exposed, upstream control, and downstream sampling zones. Data from the current study, in conjunction with historical data, will be used to evaluate whether a BIC, as defined in 40 CFR Part 125 Subpart H, is present and has been maintained within the study area.

Site selection

The study design includes three sampling zones: upstream control, thermally exposed, and downstream. The upstream control zone will include habitats upstream of the discharge that are comparable to the habitats selected for sampling in the thermally exposed zone. The thermally exposed zone will be the zone of greatest thermal exposure (e.g., > 5° F above ambient) and will begin at the discharge and extend downstream. The downstream zone will include habitats downstream of the thermally exposed zone that are comparable to the habitats selected for sampling in the thermally exposed zone. The delineation of the thermally exposed and downstream zones will be re-evaluated after conducting the preliminary hydrothermal modeling and habitat characterization and in consultation with the Missouri Department of Natural Resources (MDNR).

Habitat selection for sampling will depend on the results of the Phase I hydrothermal modeling and habitat characterization/mapping. Habitats to be sampled within the thermally exposed zone will be identified first, then comparable habitats will be selected for sampling in the upstream control and downstream zones. Factors that will be considered in selecting habitat types for sampling will include, but may not be limited to, the amount of the habitat type within the thermally exposed zone, the overall level of sampling effort, uniqueness of a habitat type and importance to productivity, and the potential to yield additional species to the inventory. Once habitat types have been selected for sampling, they will be identified using the nomenclature convention from Welker and Drobish (2012).

Each discrete area of a particular habitat type within a zone will be identified as a potential sampling site (e.g., three discrete areas of wing dike pool habitat within the thermally exposed zone will imply that there are three potential sampling sites within that zone for wing dike pool habitat). If more than one discrete sample is collected from within a sampling site, then the area from which the sample was collected will be termed the sample location. Sampling sites/locations will be selected using a stratified random design prior to the first sample collection effort. Once selected, the sites will be documented by GPS and will remain fixed for the duration of the study. The final number of sampling locations will depend on the availability of habitats and sites within the three zones with comparable physical features. Additional sites (e.g., discharge canal) may be selected to allow comparisons with historical data but not necessarily with upstream control and/or downstream sites.

As an example for this plan, the following habitat types are anticipated to be encountered and sampled. Actual habitat types for sampling will be selected after the completion of Phase I as described above.

- channel border
- wing-dike or L-dike field
- main-channel/thalweg (inside bend or outside bend)

Sample Collection

The sampling gear utilized will depend on the habitat type sampled. Multiple gears may be used for a particular habitat type to avoid gear bias and ensure a more complete inventory of the species present. Where possible, the gear specifications will either match or be close to matching those of gear used by other researchers on the lower Missouri River for data comparability. Alternatively, gear will be selected that has currently been shown to be most effective for the river conditions. Tentatively, these sampling gears by habitat type will include:

- Channel border (depths <12 ft)
  - 240-volt boat mounted pulsed-DC electrofisher[2] (for large-bodied fishes and historical data comparability)
  - 8-ft (2.44-m) head rope mini-Missouri trawl (Herzog et al. 2014) for small-bodied juvenile and adult benthic fishes

- Wing dike or L-dike field
  - 240-volt boat-mounted pulsed-DC electrofisher (for large-bodied fishes and historical data comparability)
  - 1-m towed conical plankton net with 500-μm mesh (for eggs, larvae, or early juveniles)[3]
  - 8-ft (2.44-m) head rope mini-Missouri trawl (Herzog et al. 2014) for small-bodied juvenile and adult benthic fishes

[2] Both AC and, most recently, pulsed-DC electrofishers have been used for Labadie biomonitoring programs in the past.

[3] Ichthyoplankton sampling will be limited to off-channel areas where drifting eggs and larvae may have settled, or for species that do not rely on drift and would not appear in entrainment collections

  - 30-ft x 6-ft bag seine

- Main-channel/thalweg (inside bend or outside bend)
  - 8-ft (2.44-m) head rope mini-Missouri trawl (Herzog et al. 2014) for small-bodied juvenile and adult benthic fishes

In addition, the discharge canal will be sampled using electrofishing for comparability to historical data.

The biological sample collection program for fish will be conducted over a two-year period. The frequency and duration of sample collection and the number of samples collected will depend on gear type. After each sample is collected, water depth, water temperature, dissolved oxygen, turbidity, and conductivity will be recorded at the surface and bottom using a field multi-probe (YSI meter or similar). In addition, relevant meteorological variables (e.g., air temperature, cloud cover, relative humidity, wind speed, etc.) will be obtained from the National Oceanographic and Atmospheric Administration (NOAA)/National Weather Service (NWS) Washington, MO Regional Airport station for the period of study.

Electrofishing samples will be collected once per month for 24 consecutive months, river and weather conditions permitting. One electrofishing sample of approximately 20-minute duration will be collected in each habitat type in each zone per month during the day and at night.

Trawl samples will be collected once per month for 24 consecutive months, river and weather conditions permitting. One trawl sample of approximately 3-5 minute duration over a standardized distance will be collected in each habitat type in each zone per month during the day and at night.

Seining will be conducted once per month for 24 consecutive months, river and weather conditions permitting. Two seine hauls will be conducted in the dike field habitat type in each zone per month during the day and at night.

Ichthyoplankton sampling will be conducted biweekly from mid-March through July and once per month during August and September for two years, river and weather conditions permitting. Samples will be collected by towing a 1-m conical plankton such that the entire water column will be sampled. Two, 3-5 minute duration samples will be collected in the dike field habitat type in each zone per sampling effort during the day and at night.

Sample processing
Fish collected by electrofishing, trawling, and seining will be processed in the field and returned to the river alive. All fish will be identified to species and up to 30 individuals per species will be measured and weighed. Voucher specimens for all species/taxa collected will be preserved, returned to the laboratory, and retained for a period of five years. Fish abnormalities using the deformities, erosion, lesions, and tumors (DELT) method will be noted and recorded. Any endangered species encountered (e.g., pallid and lake sturgeon) will be reported and handled per standard USFWS methods/directions.

Ichthyoplankton (eggs, larvae, and early juveniles) will be preserved in the field with a 10% formalin/rose bengal solution and returned to the laboratory for taxonomic analysis.

Data analysis
All data collected during the fish surveys will be entered into a Microsoft Access or similar database. The fish community will be characterized by zone and habitat type. In addition, it is anticipated that the following or similar metrics will be reported:

- Catch-per-unit-effort (number and biomass)
- Community metrics such as species richness, species diversity, species dominance
- Percent pollution tolerant species
- Length-frequency distributions for selected species
- Mean relative weight for game and protected species

Detailed methods for each sample collection gear type as well as sample processing and sample analysis (e.g., taxonomic) methods are provided in the Standard Operating Procedures (SOPs) and Quality Assurance Project Plan (QAPP) that accompany this study plan.

4.2.2 Benthic Macroinvertebrate and Shellfish Surveys

Objective(s)
To document and compare the presence and relative abundance of the benthic macroinvertebrate taxa in the thermally exposed, upstream control, and downstream zones. The data from the current study, in conjunction with historical data, will be used to evaluate whether a BIC, as defined in 40 CFR Part 125 Subpart H, is present within the study area.

Site selection
The study design is based upon the same three sampling zones (i.e., upstream control, thermally exposed, and downstream zones) and habitat type and sampling site identification and selection methods used for the fish sampling. Up to three sampling sites will be selected within each habitat type within each zone prior to the first sample collection effort. Once selected, the sites will be documented by GPS and will remain fixed for the duration of the study. The final number of sampling locations will depend on the availability of habitats and sites within the three zones with comparable physical features. The discharge canal will also be sampled for comparability to historical data.

As an example in this plan, the following habitat types are anticipated to be encountered and sampled. Actual habitat types for sampling will be selected after the completion of Phase I as described above.

- Depositional; and
- Rock/gravel (primarily expected to be associated with wing dikes and revetments).

Sample Collection
The biological sample collection program for benthic macroinvertebrates and shellfish will be conducted quarterly for a period of 2 years.

For depositional habitats, samples will be collected using a standard ponar dredge from three randomly selected locations within each site and composited for analysis. An additional sample will be collected from each site for qualitative grain size analysis.

Rock/gravel habitats will be sampled using H-D sampling arrays. Each array will consist of two samplers. At each of three selected locations within each sampling site, one H-D array will be deployed for benthic sample collection and one array will be set for mid-water column sample collection. This will yield a total of six H-D sampling arrays deployed within each sampling site. Samplers will remain deployed for a period of six weeks during each quarter. After the first year of sampling is complete, the H-D data will be evaluated to determine whether to continue the dual deployment or to continue with either the benthic or mid-water deployment.

At each sampling site, each sample and the surrounding area will be visually inspected for the presence of native mussels/mussel shells. In addition, native mussel shells found in trawls will be noted. Any native mussels/mussel shells found will be identified to species to determine whether any threatened and endangered species are present.

At each sample collection location, water depth, water temperature, dissolved oxygen, turbidity, and conductivity will be recorded at the surface and bottom using a field multi-probe (YSI meter or similar). In addition, relevant meteorological variables (e.g., air temperature, cloud cover, relative humidity, wind speed, etc.) will be obtained from the National Oceanographic and Atmospheric Administration (NOAA)/National Weather Service (NWS) Washington, MO Regional Airport station for the period of study.

Sample processing
Standard ponar dredge samples will be sieved in the field using a 0.5-mm mesh bucket sieve. All organisms, detritus, debris, and sediments from the sieve bucket will be carefully removed from the sieve into a sample container and preserved with a 10% formalin/rose bengal solution. All samples will be returned to the laboratory for taxonomic analysis.

Hester-Dendy samplers will be retrieved and placed in individual sample containers containing a 10% formalin solution with Rose Bengal stain and transported back to the laboratory for processing. In the laboratory, sampler plates will be removed and carefully scraped to remove all organisms. The remaining contents of the sample container will be sieved using a 0.5-mm mesh sieve to collect any organisms dislodged during transport. Samplers and each sample location within a site will be processed separately.

In the laboratory, samples will be subsampled to a minimum quota of 200 organisms as described in the SOP. Organisms will be identified to the lowest practicable taxonomic level. Voucher specimens will be retained for all species/taxa collected and will be retained for a period of 5 years.

Data analysis
All data collected during the benthic macroinvertebrate and shellfish surveys will be entered into a Microsoft Access or similar database. The benthic macroinvertebrate community will be characterized by zone and habitat type. Benthic macroinvertebrate habitat and community analysis will include, but may not be limited to, the following metrics:

- density (#/m^2)
- taxa richness
- dominant taxa
- EPT index
- Biotic index
- Shannon diversity index
- qualitative sediment characterization (percent abundance of particle types, Wentworth scale)

Detailed methods for each sample collection gear type as well as sample processing and sample analysis (i.e., taxonomic) methods are provided in the SOP and QAPP documents that accompany this study plan.

5. BIOTHERMAL ASSESSMENT

A retrospective biothermal assessment will be conducted to evaluate whether the thermal discharge is preventing the protection and propagation of the BIC in the Missouri River in the vicinity of the LEC. Because there are no State criteria for evaluating whether a thermal discharge threatens the protection and propagation of a BIC, the following sources of guidance will be used:

- USEPA draft guidance manuals (Draft 316(a) Guidance) issued for the implementation of Section 316(a) of the Clean Water Act (CWA) in 1974, 1975, and 1977 (USEPA 1974, 1975, 1977);
- 40 CFR Part 125 Subpart H;
- Professional practice in prior Section 316(a) assessments at other generating stations; and
- Guidelines for Ecological Risk Assessment (ERA Guidance) recommending approaches and criteria for assessing impacts from chemical, physical, or biological stressors (USEPA 1998a)

In general, USEPA has determined that a community need not be protected from mere "disturbance," but rather that communities will be adequately protected if "appreciable harm" is avoided. According to USEPA, "appreciable harm" occurs if a thermal discharge causes such phenomena as the following:

- Substantial increase in abundance of any nuisance species or heat-tolerant community not representative of the highest community development in the lower Missouri River;
- A decrease in indigenous species of the lower Missouri River;
- Changes in community structure of the lower Missouri River to resemble a simpler successional stage;
- A substantial reduction in community heterogeneity or trophic structure;
- Reduction of successful completion of life cycles of indigenous species;
- Impairment of a zone of passage to the extent that it will not provide for the normal movement of populations of RIS, dominant species of fish, and economically important species of fish, shellfish, and wildlife;
- Adverse impact on threatened or endangered species; or
- The elimination of an established or potential economic or recreational use of the lower Missouri River.

The biothermal assessment process will consist of three sequential steps:

- Evaluation of Biotic Category vulnerability;
- Retrospective ["No Prior Appreciable Harm (NPAH)] evaluation of biothermal impact; and
- Evaluation of Balanced Indigenous Community (BIC) protection and propagation.

5.1 BIOTIC CATEGORY VULNERABILITY

Biotic category vulnerability will be assessed using the Critical Function Zone (CFZ) and Biotic Category (BC) methods recommended by the USEPA Draft 316(a) Guidance. The vulnerability evaluation screens out those biotic categories that have low potential for impacts from LEC's thermal plume (LPI categories), and focuses the retrospective, no prior appreciable harm (NPAH), assessment on the remaining biotic categories.

5.2 RETROSPECTIVE ASSESSMENT

Whether the LEC's operations and thermal discharge has caused appreciable harm to fish and macroinvertebrate and shellfish communities will be evaluated using a retrospective biothermal assessment.

Methods for the retrospective evaluation will include:

- Comparison of species/taxa composition and abundance among samples from the three zones (thermally exposed, upstream control, downstream) in the planned biological studies;
- Comparison of the species/taxa composition and abundance observed in the present study to that reported in historical studies; and
- Review of existing information on the status of, and trends in, the biological community and water quality in the lower Missouri River.

Differences among the three zones will be examined for evidence of exposure and response relationships and the potential influences of other ecological factors to the extent possible.

5.3 PREDICTIVE BIOTHERMAL ASSESSMENT

As discussed in Section 2.3, a predictive biothermal assessment may be conducted depending on the results of the biological monitoring, retrospective assessment, and the need for a comprehensive variance. The following section provides an overview of the anticipated predictive biothermal assessment approach, if it is performed. In the event a predictive biothermal assessment will be conducted, a more detailed methodology will be developed and presented for MDNR review.

5.3.1 Representative Important Species

USEPA's 1977 Draft 316(a) Guidance recognizes that it is impractical to study and assess in great detail every species at a site, and it is therefore necessary to select a smaller group to be representative of the balanced indigenous community. These selected species are designated as representative important species (RIS). Generally, five to 15 RIS are selected to represent the community. According to the Draft 316(a) Guidance, RIS are to include species that are:

- Representative, in terms of their biological requirements, of a balanced indigenous community of fish, shellfish, and wildlife;
- Commercially and recreationally valuable;
- Threatened or endangered;
- Critical to the structure and function of the ecosystem (e.g., habitat formers);
- Potentially capable of becoming localized nuisance species; and
- Necessary in the food chain for the well-being of species determined above.

Other considerations for RIS selection include the extent of the species involvement with the thermal plume, the species thermal sensitivity, and the quantity and quality of information available for the assessment.

The selection of RIS will include consultation with, and input from, the MDNR.

5.3.2 Predictive Assessment

The potential for impact would be evaluated by predicting the nature and likelihood of potential thermal effects on individual organisms, and then assessing the significance of those effects on the RIS populations. In the language of USEPA Draft Section 316(a) Guidance, the significance of effects equates to their potential for causing “Appreciable Harm”. The nature and likelihood of thermal effects will be characterized by comparing the habitat preferences, seasonal occurrence, and temperature requirements or limits of each species to thermal exposures that could potentially occur as a result of the LEC’s operations.

A thorough review of the literature on thermal response temperatures, life history information, and seasonal occurrence in the vicinity of the LEC would be conducted. The results of the biological monitoring studies would also be used as a component of the predictive assessment.

A state-of-the-art hydrothermal model would be selected and used to estimate exposure temperatures and durations of exposure under a variety of river flow, meteorological, river temperature, and plant operating condition scenarios. The resulting exposure scenarios would be compared to the biological and thermal response information obtained from the biological monitoring studies and the scientific literature to evaluate whether biological effects of LEC’s thermal discharge are sufficiently large to jeopardize the health of six trophic level components (biotic categories) and RIS populations selected to represent the BIC.

6. REPORTING

As specified in the LEC NPDES permit, annual progress reports will be submitted to the MDNR by February 28 of each year. In the event that modifications are necessary to the sampling plan to address unforeseen circumstances, the MDNR will be notified of the potential change(s) as early as possible in the process to solicit comments/feedback.

A final report detailing the results and conclusions of the biological monitoring study and, if necessary, a renewed 316(a) demonstration will be submitted with the permit renewal application six months prior to the existing permit expiration.

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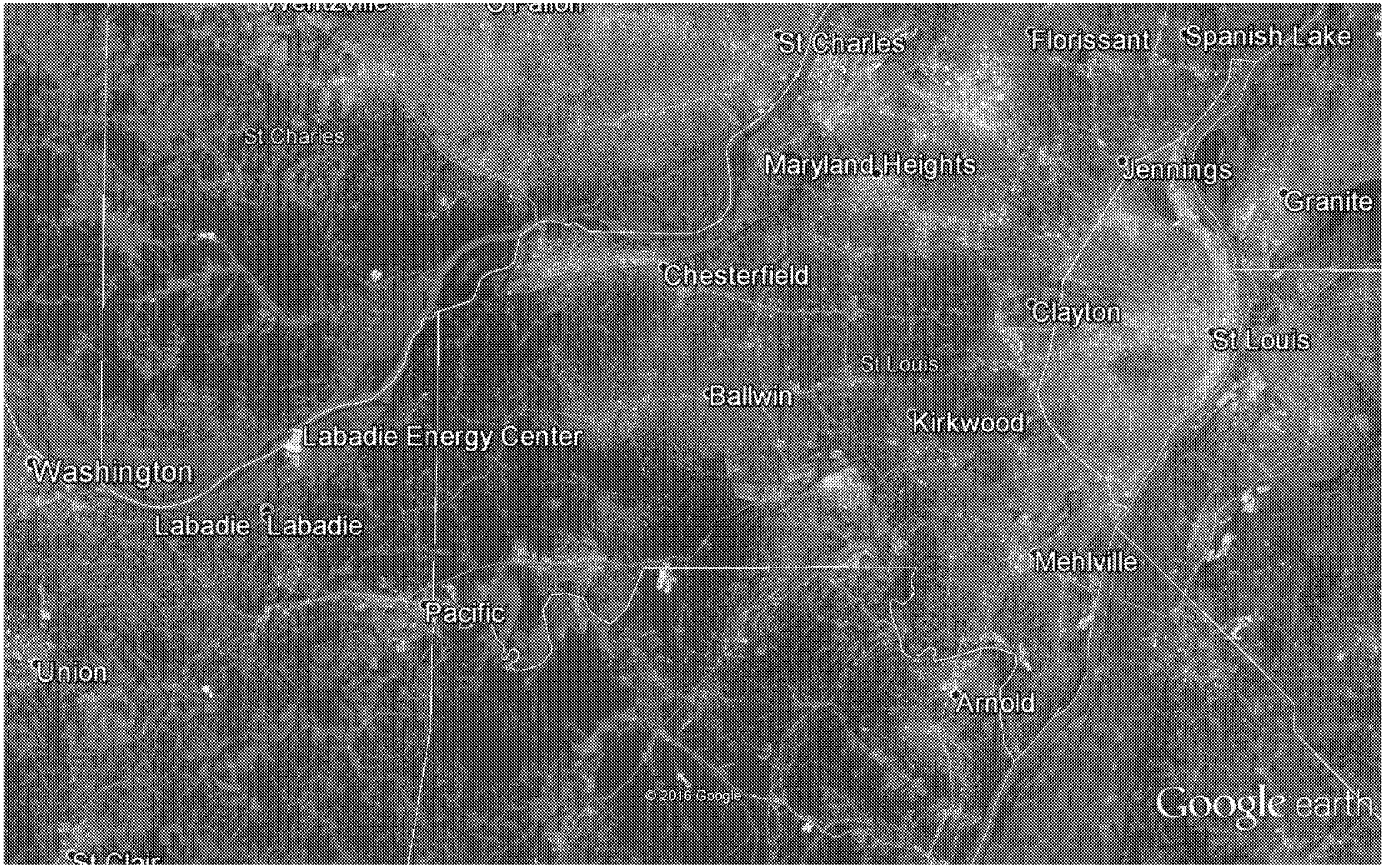

Figure 1 Aerial photograph showing the general geographical location of the LEC (Source: Google Earth)

Figure 2. Aerial photograph of the LEC showing the cooling water intake and discharge canal (Source: Google Earth)

AMEREN MISSOURI LABADIE ENERGY CENTER
316(A) STUDY PLAN

ADDENDUM 1
HABITAT CHARACTERIZATION AND SAMPLING SITE SELECTION

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1 INTRODUCTION AND PURPOSE

This addendum summarizes refinements to the Labadie Energy Center (LEC) 316(a) Study Plan resulting from work performed on hydrothermal modeling (Section 3 in the Study Plan), habitat characterization (Section 4.1), and site selection (Sections 4.2.1 and 4.2.2), which has been completed subsequent to the initial preparation of the Study Plan.

As outlined in the Study Plan, hydrothermal modeling was performed to predict the spatial extent of the thermal plume under varying environmental and station operating conditions. A desktop habitat mapping exercise was then conducted using existing information to identify the riverine habitat types within the study area. After completion of a preliminary habitat map, site selection included a field reconnaissance trip to evaluate the accuracy of the habitat map and identify other potential riverine habitat features that may influence the selection of the sample collection locations. Finally, a "ground-truthing" effort was conducted to further evaluate the conditions of specific sampling sites and confirm the feasibility of access and sample collection.

The addendum is organized into three main sections that summarize the results of the work performed. These sections are:

- Section 2: Hydrothermal Modeling
- Section 3: Habitat Characterization
- Section 4: Site Selection

2 HYDROTHERMAL MODELING

2.1 INTRODUCTION

A state-of-the-art hydrothermal model was used to conduct preliminary hydrothermal modeling under varying scenarios of river and plant operation conditions to simulate the potential spatial extent of the thermal plume. To facilitate the selection of sampling sites, a predicted water temperature difference (ΔT) of 3°F or more above ambient river temperature was used to define river areas where plume temperatures could exceed natural daily water temperature variations[1], to which resident organisms were presumed to be well adapted. This area encompassing predicted temperatures $\geq$3°F was defined as the "thermally exposed zone". A "downstream zone" was defined as the river reach starting at the downstream end of the thermally exposed zone, and an "upstream control zone" was defined as the river reach upstream of the LEC intake and discharge outfall. These three primary zones comprised the study area for the initial Labadie 316(a) study plan (Section 2.2 of the Study Plan). Ameren subsequently identified a fourth zone—the "discharge zone"—that had been previously included in historical sampling programs. This zone is represented by the discharge canal and the area immediately below the canal extending to the first wing dike (see Section 2.3, below). The discharge zone will be sampled using electrofishing for fish and a Ponar dredge and Hester-Dendy samplers for benthic macroinvertebrate sampling to allow a comparison with historical data collected using the same methods.

2.2 MODEL SELECTION AND SCENARIO OVERVIEW

The FLOW-3D computational fluid dynamics model (Flow Science, 2016) was selected for modeling three-dimensional mixing of the LEC thermal discharge with the Missouri River. This model was deemed appropriate for this application because of its ability to simulate both near-field and far-field mixing and to accommodate complex river features such as variable bathymetry, bars, islands, and dikes that are present in the Missouri River. As described in Section 3 of the Study Plan, available bathymetric data from the U.S. Army Corps of Engineers collected in 2001, 2007, 2009, 2013, and 2014 were used to adapt the model to the Missouri River in the vicinity of the LEC.

Available field-collected water temperature measurements from July and August 2003, January 2004, and January and April 2016 were used to validate the hydrothermal model. For each survey, either nine or 10 transects were sampled from the discharge canal to approximately 1 mile downstream. Transects were spaced approximately 500 yards apart in the downstream direction. Temperature measurements were collected every 100 feet across each transect and every 2 feet vertically from the surface to the bottom.

Available river flow and river temperature data from USGS Hermann gage 06934500 and LEC operating (discharge flow and temperature) data from 2002-2015 were used to develop model scenarios that would encompass a potential range of conditions that could influence the downstream and cross-river extent of the thermal discharge. Combinations of high and low river flows and temperatures and full-load plant operating conditions (discharge flow and temperature) were modeled to evaluate changes in the predicted extent of the thermal plume. As would be expected, model simulations generally showed that the predicted thermal plume reached farther downstream at lower river flows regardless of the water temperature.

[1]Conservatively based on a typical daily water temperature range of 1-2°F recorded at USGS gage 06935550, upstream of the LEC cooling water discharge outfall

2.3 SAMPLING ZONE DELINEATION

Sampling zones were delineated to facilitate the selection of the biological sample collection locations by dividing the study area based on the expected degree of exposure to excess temperature (i.e., temperatures above ambient river water temperature) from the LEC thermal discharge. The division of the study area into sampling zones helps to account for the variable nature of the thermal plume over space and time.

A general review of the thermal plume maps produced by the preliminary modeling showed that excess river temperatures predominantly stayed associated with the right descending river bank and extended furthest downstream under low flow conditions. Excess temperatures were highest and most consistently present in the discharge canal and just downstream of the confluence with the Missouri River to the first dike, located at approximately river mile (RM) 57.25. Based on the latter observation, and considering the discharge area would experience an exposure scenario different from habitats further downstream and had been sampled historically, it was determined this area should constitute an additional sampling zone. This additional sampling zone, the discharge zone, was delineated to include the discharge canal and the outer bend habitat along the right descending bank (from the thalweg to the bank) downstream to the first dike.

A more detailed evaluation of the preliminary modeling of the thermal plume was conducted to determine the appropriate downstream extent for the thermally exposed sampling zone. The first step was to identify the excess temperature isotherm that would guide the downstream extent decision. An excess temperature of 3°F (i.e., 3°F above the ambient river water temperature) was selected as the most representative isotherm to delineate the downstream extent of the thermally exposed zone. The 3°F excess temperature isotherm was selected for the reasons described above in Section 2.1. In addition, at the highest modeled ambient water temperature of 87° F, the 3° F excess temperature isotherm corresponds to the 90° F isotherm (the Missouri water quality standard for maximum temperature). The 87° F ambient water temperature represents the upper 99th percentile of the daily averaged water temperature data from 2002 through 2015.

This evaluation showed that under river flow conditions of approximately 31,000 cfs, the 3°F excess temperature isotherm was present downstream to approximately RM 52. Based on river discharge data for 2002 to 2015 from the USGS Hermann gage 06934500, flows of 31,000 cfs or less occurred about 5% of the time. Based on these observations, the thermally exposed zone for sample collection was determined to extend from the start of the first dike (approximately RM 57.25) downstream of the discharge canal downstream to approximately RM 52 (Figure 2-1).

The downstream zone was defined as the zone downstream of approximately RM 52 to approximately RM 50. The upstream control zone was selected to be between approximately RM 58.5 and RM 62, well upstream of any potential influence from the LEC intake and discharge. Both zones contain habitat types comparable to those found in the thermally exposed zone, as described in detail below in Sections 3 and 4.

The following revised four sampling zones comprise the LEC 316(a) study area:

- An upstream control zone unaffected by the LEC intake or discharge (RM 58.5 – RM 62),
- A discharge zone encompassing the area of highest potential exposure to the thermal discharge (RM 57.5 – RM 57.25)

- A thermally exposed zone where any potential effects from thermal discharge would be expected if present (RM 57.25 – RM 52), and

- A downstream zone which potentially could experience minor and transient exposure to the thermal discharge (RM 52 – RM 50).

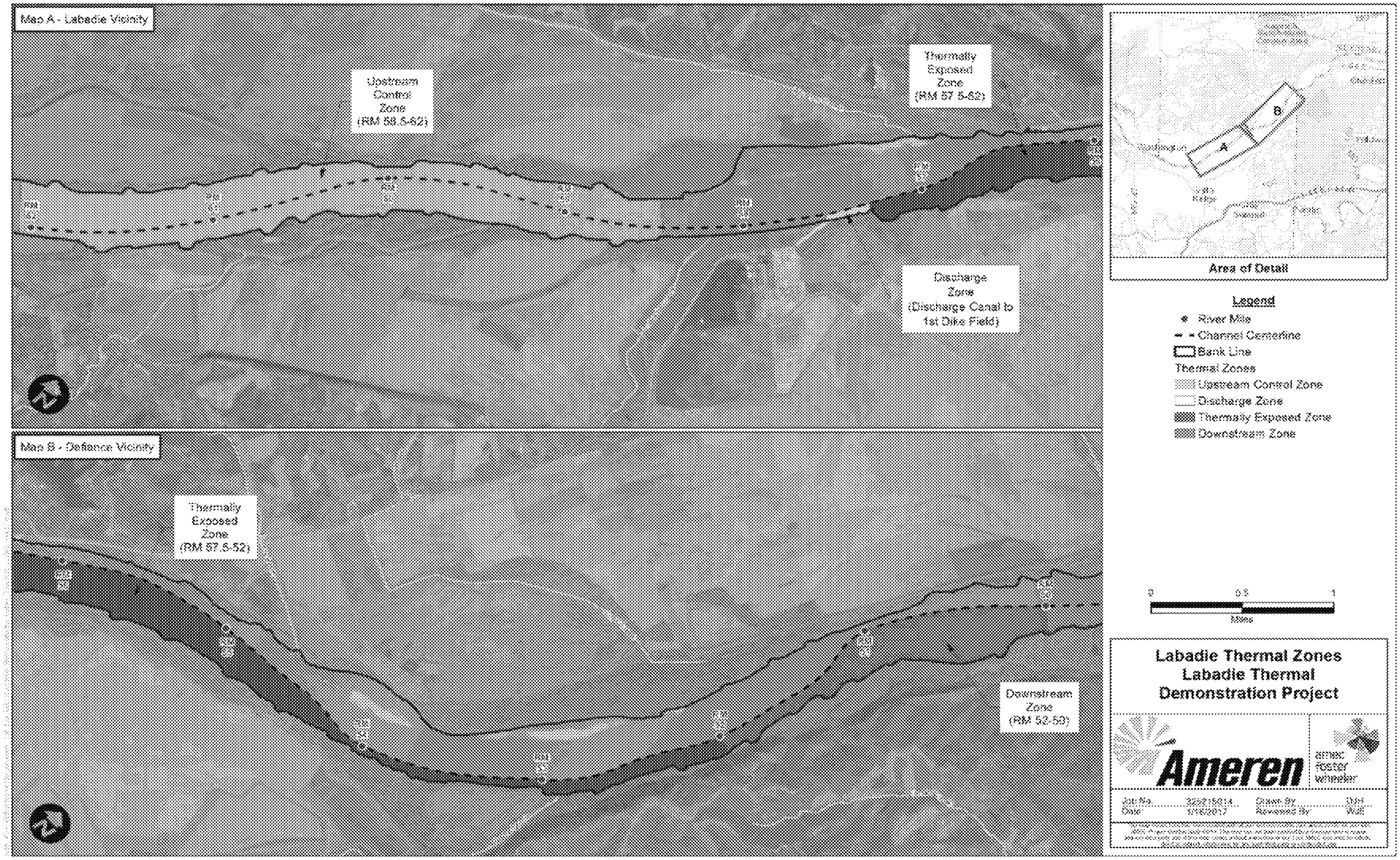

Figure 2-1. **Four Sampling Zones Identified within the Primary Study Area Based on Thermal Plume Mapping for Labadie Energy Center 316(a) Thermal Demonstration**

3 HABITAT CHARACTERIZATION AND PRELIMINARY SITE SELECTION

3.1 INTRODUCTION

Once the sampling zones were approximated, a desktop habitat characterization mapping was conducted using available data to identify the habitats within each of the sampling zones. The habitat characterization map was used to identify the key habitat types that were substantively present in the thermally exposed zone and that would be the focus of the biological sample collection program. After identifying the preliminary habitat types for sampling in the thermally exposed zone, the habitat characterization map was used to identify similar habitats in the upstream control and downstream zones.

3.2 METHODS

The desktop characterization of the potential habitat types in the sampling zones was conducted by reviewing existing sources of data and information on the Missouri River in the vicinity of the LEC. These sources included bathymetric data, river morphometry, aerial photography, and navigational charts. National Wetland Inventory maps were also added to the habitat characterization for reference, as many of the palustrine wetlands associated with riverine environments are periodically flooded during high river stage and provide important functions related to life cycles of aquatic biota. Coverages of NWI wetlands, however, were modified at the boundary of the Missouri River to eliminate gross inaccuracies of NWI mapping (e.g., mapping of forested wetlands within the river area).

Habitats were classified using the hierarchical system described by Welker and Drobish (2010) as a guide. Their system consists of macrohabitats, mesohabitats, and microhabitats which allows for both general and specific categorization for sampling to serve the needs for biological and physical data collection efforts.

The preliminary habitat characterization mapping effort was conducted for the entire anticipated reach of the study area from approximately RM 62 downstream to approximately RM 50 and included both right and left descending banks.

3.3 APPLICATION OF THE CLASSIFICATION SYSTEM TO THE STUDY AREA

Welker and Drobish (2010) identified three tiers of habitats: macrohabitats, mesohabitats, and microhabitats. During the desktop habitat characterization effort, macrohabitats were identified and mapped first (Figure 3-1). A more detailed evaluation of the information was then conducted to identify the key mesohabitats and microhabitats present in the study area. These are shown in the figures in Appendix A.

3.3.1 Macrohabitats

Delineation of macrohabitats was undertaken in a step-wise fashion. Close examination of bathymetric data was undertaken to identify the location of the main channel center within the LEC reach. Cross sections were then "cut" every one-half mile to assist in delineation of the main channel and its location within the broader river valley. Finally, general river morphology was examined along with noting the occurrence of side channels, secondary channels, and tributary mouths. Using this information, the general limits of the macrohabitats were approximated longitudinally within the LEC reach. The macrohabitats identified within the LEC reach included:

- Main Channel Crossover (CHXO)
- Main Channel Outside Bend (OSB)
- Main Channel Inside Bend (ISB)
- Secondary Channel-Connected (Large) (SCCL)
- Secondary Channel-Connected (Small) (SCCS)
- Tributary Small Mouth (TRMS)

Only Secondary Channel-Connected (Large and Small) macrohabitat types did not occur in the thermally exposed zone (i.e., river mid-line to right descending bank from approximately RM 57.25 to RM 52) and were, therefore, not identified for potential sample collection. The locations of the macrohabitats within the study area are shown in Figure 3-1.

3.3.2 Mesohabitats

Mesohabitats within the LEC reach occur within the identified macrohabitats and are shown in the figures presented in Appendix A. Mesohabitats present in the study area include:

- Thalweg
- Channel Border
- Pools
- Bars
- Island Tips

Thalweg and channel border habitats are ubiquitous within the study area and account for most available habitat. Pool habitats are primarily represented in association with identified dike fields. Bars and island tips, while present, were less common.

3.3.3 Microhabitats

Microhabitats are also identified within the LEC reach and are shown in the figures presented in Appendix A. The entire LEC reach is variously composed of dikes that are river training structures that function to maintain the navigation channel. While Welker and Drobish (2010) identified several different types of dike microhabitat, the current habitat characterization only differentiated between wing dikes and L-dikes. The following microhabitats were identified within the study area:

- Wing Dikes
- L-Dikes
- Channel Sand Bar
- Bank Line
- Chute

3.3.4 Observed Data Gaps

Several data gaps were identified during the desktop habitat characterization mapping effort. These data gaps include the following:

1. *Channel border and side channel depths.* Several channel border and side channel areas (SCCS and SCCL) lack sufficient bathymetric information to confirm water depth and habitat characteristics. Such areas are expected to be inundated during high water levels and would be expected to support aquatic biota of varying life stages. However, insufficient information is available to fully understand water depth and relative use by aquatic biota during periods of low flow and potentially elevated thermal conditions.
2. *Aberrant bathymetric readings.* In selected locations detailed bathymetric data suggested the presence of bottom elevations that were suspect. For example, in several locations higher elevations suggested the presence of a "shallow" or bar within a portion of an area expected to be the thalweg. Such readings may be aberrant and should be verified and corrected, as appropriate.
3. *Main channel connectivity.* Based on aerial photo review, several existing and relict side channels were identified. Several side channels were identified that clearly connect to the main channel. In contrast, the connectivity of other selected relict channels could not be verified using office-level information.
4. *Dike field characteristics.* Limited work was previously performed in the dike field immediately downstream of LEC (right descending bank) in support of hydrothermal modeling efforts. Using aerial photographs the limits and configuration of other dike structures in the LEC have been identified in Appendix A. These preliminary configurations and the particular type of dike should be field verified to more fully understand the potential characteristics of these microhabitats and their associated pool mesohabitats.
5. *Pool Definition.* The criteria for delineation of pools indicates that pool mesohabitats are areas immediately downstream from sandbars, dikes, snag-piles, or other obstructions that have formed a scour hole >1.2 meters deep. Pool habitats identified in Appendix A require refinement to confirm water depths at each location and refine limits of pools.

An attempt was made to collect the appropriate data to fill these data gaps during the field reconnaissance and ground-truthing efforts (Sections 4.2 and 4.4 below).

3.4 PRELIMINARY HABITAT TYPES IDENTIFIED FOR SAMPLING

Based upon the desktop habitat characterization mapping, six macro/meso/microhabitat combinations were identified as potential sampling sites pending the outcome of the field reconnaissance and ground-truthing surveys. The habitat types selected for sampling in the upstream control, thermally exposed, and downstream zones and the number of discrete locations for each habitat type are presented in Table 3-1. Because data collected from the discharge zone is intended only for comparison with historical studies, the discharge zone is not included in Table 3-1.

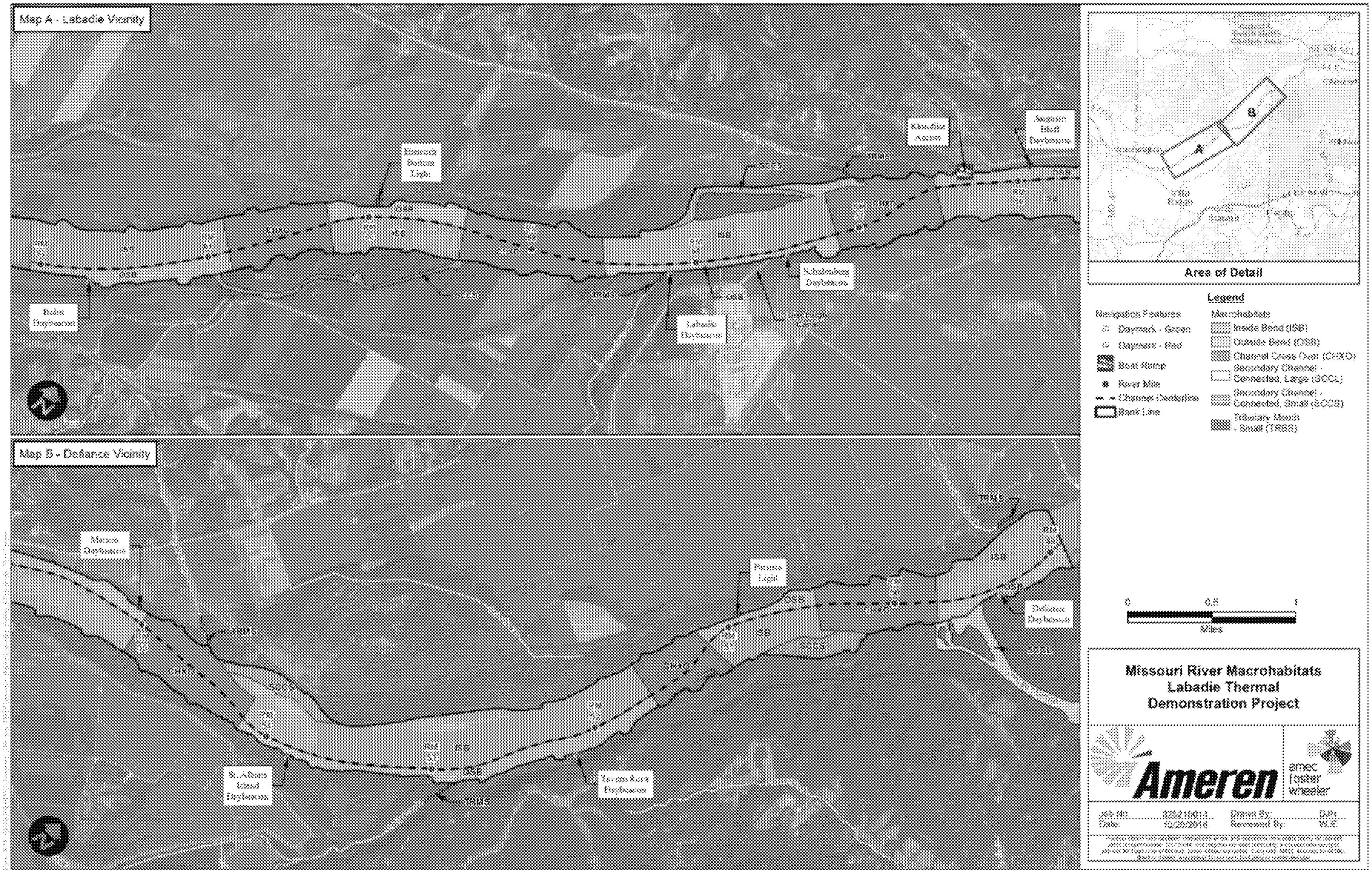

Figure 3-1. **Macrohabitats Identified within the LEC Study Area**

Table 3-1. **Number of Macrohabitat and Mesohabitat Types Present within the Upstream Control, Thermally Exposed, and Downstream Zones.**

Sampling Zone	Macrohabitat	Mesohabitat	Number of Habitats Present
Upstream Zone	Outside Bend	L-dike/Pool	6
	Main Channel Crossover	L-dike/Pool	4
	Main Channel Crossover	L-dike/Bar	1
	Inside Bend	W-dike/Pool	5
	Inside Bend	W-dike/Bar	2
	Inside Bend	Channel Border	~ 2.25 miles
Thermally Exposed Zone	Outside Bend	L-dike/Pool	9
	Main Channel Crossover	L-dike/Pool	3
	Main Channel Crossover	L-dike/Bar	1
	Inside Bend	W-dike/Pool	4
	Inside Bend	W-dike/Bar	2
	Inside Bend	Channel Border	~ 1.5 miles
Downstream Zone	Outside Bend	L-dike/Pool	2
	Main Channel Crossover	L-dike/Pool	2
	Main Channel Crossover	L-dike/Bar	2
	Inside Bend	W-dike/Pool	1
	Inside Bend	W-dike/Bar	2
	Inside Bend	Channel Border	~ 0.75 miles

4 FIELD RECONNAISSANCE AND SAMPLING SITE SELECTION

4.1 INTRODUCTION

During the site selection process, the habitat types initially identified for sample collection using desktop habitat characterization mapping were evaluated in the field during reconnaissance and ground-truthing trips. These trips also were used to collect data to fill data gaps identified by the desktop exercise (Section 3.3.4 above). The combination of desktop habitat characterization mapping and field reconnaissance information was then used to select specific sample collection locations for each habitat type in each sampling zone. The more detailed data collected during the ground-truthing survey were used in the development of the sample collection standard operating procedures.

4.2 FIELD RECONNAISSANCE

A field reconnaissance survey was conducted on October 26, 2016 to identify features associated with each habitat including, but not limited to, shoreline type, geomorphological features, water depth, flow, and substrate type. The field reconnaissance also allowed the identification of specific features of mesohabitats (e.g., bars, collapsed dikes, notches in dikes, etc.) that were not observed from available aerial photography data used as part of the habitat characterization study. In addition, the applicability of sampling gears for each substantially present habitat type was assessed.

The information collected during the reconnaissance survey supported the macrohabitat classification performed during the desktop mapping and no changes to the mapped macrohabitat types were necessary. Several newly formed sand bar mesohabitats (e.g., bars at RM 58.75, RM 56.8, RM 55.6 and RM 51.5) were identified and recorded as potential sampling locations. Substrate types of these sand bars were dominated by sand and gravel. Other sand bars identified by the desktop habitat characterization consisted of compacted clay and silt.

While no new microhabitat types were identified during the reconnaissance survey, several key observations were made regarding the condition of many of the dikes. Notches or openings in dikes were noted and their respective GPS coordinates taken. Flow characteristics (e.g., back eddy flow) immediately behind dikes created by notch openings were also noted. Recently collapsed dike tips (e.g., wing dikes from RM 61 to 62) not previously observed from available aerial photography data were documented. The observations regarding the condition of the dikes was used in the selection of specific sampling locations as described in Section 4.3.

General depth profiles around dikes and bars were recorded to guide sample site selection and assess the potential applicability of sampling gear types. On the day of the reconnaissance survey when depth profiles were recorded, the river gage height was 5.81 feet and river discharge was approximately 66,000 cfs. While depth profiles varied slightly, the depth immediately off dike fields generally ranged from 6 to 8 feet, providing an ideal habitat type for electrofishing. Depths surrounding sand bar habitats varied substantially depending on the slope of banks, ranging from 1 to 13 feet. Bars ideal for bag seining had surrounding depths of 1-3 feet and were mostly composed of sand substrate. Dikes predominantly were composed of boulders, large cobble, and wood pilings. Shoreline substrate within the study area was predominantly compacted clay and silt, with sporadic fallen trees and woody debris providing potential habitat structure for fish.

Maps showing the mesohabitat and microhabitat types identified through the desktop mapping and the reconnaissance survey are presented in Appendix A. Photographs of representative mesohabitats and microhabitats substantially present within the 13-mile study reach are presented in Appendix B.

4.3 SITE SELECTION RATIONALE

Specific sampling sites for fish and benthic macroinvertebrate surveys were selected based on the results of the habitat characterization study and field reconnaissance surveys, which aided in determining dominant habitat types present within the study area and their comparability among thermally exposed and non-exposed sections of the river. As described in the study plan (Sections 4.2.1 and 4.2.2), sample collection locations within the thermally exposed zone were identified first, then comparable habitat types and locations were identified in the upstream control and downstream zones. Based on the results of the hydrothermal modeling, the habitat types identified for sampling in the thermally exposed zone were limited to the area from the river center-line to the right descending bank. The reconnaissance field survey provided information with which to evaluate the suitability of each area of a particular habitat type for sampling and to identify the preferred representative sample location for that habitat type. The locations selected for sample collection by habitat type are shown in the figures presented in Appendix A. The number of habitat types per zone and the anticipated sample collection gears for each habitat type are shown in Table 4-1.

The initial study plan (Section 4.2 in the Study Plan) tentatively identified three basic habitat types that were expected to be encountered in the study area pending the completion of Phase I – Habitat Survey and Characterization of the Study Plan (Section 4.1 in the Study Plan). Based on the completion of the desktop habitat mapping and the field reconnaissance survey described in this addendum, a total of six unique habitat types were identified for sample collection in the thermally exposed zone (Table 4-1). Outside Bend–L-dike/Pool habitats were the most abundant habitat type within the thermally exposed zone.

Identification of representative sample locations for each habitat type were dependent on the suitability of each specific location for sampling and comparability with sampling locations identified in the thermally exposed zone. In some cases, Outside bend–L-dike/Pool fields did not have notches, preventing access to sampling locations (e.g., upstream control field at RM 61.5, downstream L-dike/Pool at RM 51.75). In other cases, Inside bend–Wing-dikes were partially or fully collapsed (e.g., upstream control field at RM 61 to 62). Sampling locations identified for bag seining included two bars within each major zone, located on inside bends behind or in front of wing-dikes and behind main channel crossover L-dikes. Each of these locations had a mostly sand/gravel substrate and gradual drop-off with sufficient area present for several seine hauls. Other bars initially identified from aerial photography within each sampling zone were not selected because they were found to be unsuitable for bag seining (i.e., substrate composed of mud/clay and steep drop-offs).

In total, 19 discrete sampling locations were identified: six in each of the three major sampling zones and one for the discharge zone (Table 4-1).

4.4 GROUND-TRUTHING SURVEYS

Detailed ground-truthing surveys were completed on November 17 and November 29, 2016 to fill data gaps identified by initial habitat characterization and the field reconnaissance survey. Bathymetric surveys were conducted in areas with insufficient bathymetric data for each sampling location identified during the field reconnaissance survey. Potential locations for each collection method and gear type were mapped using GPS for each sampling location. Sediment composition was documented for locations selected for macroinvertebrate sampling. The extent of each L-dike and wing-dike proposed for sample collection also was documented, including their upstream and downstream limits, horizontal limits, and height to determine when that dike may become submerged, as well as the location and flow velocity through notches or openings. These data were used in the development of more detailed Standard Operating Procedures, including updated maps of each sampling location, to be used by field crews during sampling.

Table 4-1. **Proposed Sampling Locations and Gear Types for Macrohabitats and Mesohabitats within each Sampling Zone**

Sampling Zone	Macrohabitat	Mesohabitat	Approximate River Mile	Electrofishing	IP Tows	Bag Seine	Benthos*	Hoop Net	MO-trawl
Upstream Control Zone	Inside Bend	Channel Border	61.5						✓
	Outside Bend	L-dike/Pool	61.2	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Pool	60.5	✓	✓		✓	✓	✓
	Inside Bend	W-dike/Pool	60	✓	✓		✓	✓	✓
	Inside Bend	W-dike/Bar	60			✓			
	Main Channel Crossover	L-dike/Bar	58.75			✓			
Discharge Zone	NA	NA	57.5	✓			✓		
Thermally Exposed Zone	Outside Bend	L-dike/Pool	57.25	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Bar	56.8			✓			
	Main Channel Crossover	L-dike/Pool	56.6	✓	✓		✓	✓	✓
	Inside Bend	Channel Border	56.25						✓
	Inside Bend	W-dike/Bar	55.6			✓			
	Inside Bend	W-dike/Pool	55.6	✓	✓		✓	✓	✓
Downstream Zone	Outside Bend	L-dike/Pool	52.25	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Pool	51.5	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Bar	51.5			✓			
	Inside Bend	W-dike/Bar	51			✓			
	Inside Bend	W-dike/Pool	50.9	✓	✓		✓	✓	✓
	Inside Bend	Channel Border	50.75						✓

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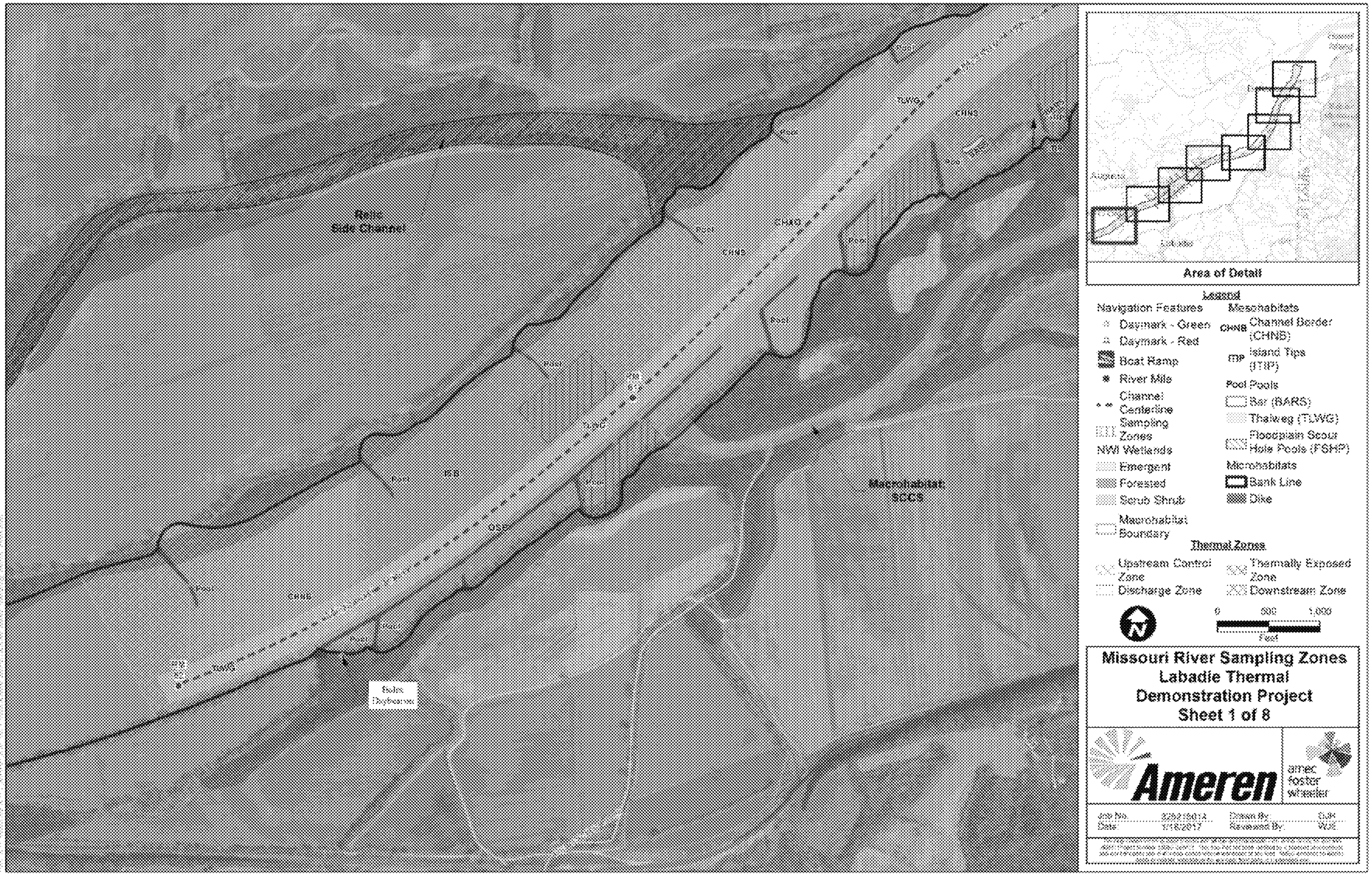
APPENDIX A
Mesohabitats, Microhabitats, and Sampling Locations Identified within the LEC Study Area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CHNB
TLWG
OSB
ISB
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River Mile
Channel Centerline
Sampling Zones
NWI Wetlands
Emergent
Forested
Scrub Shrub
Macrohabitat Boundary
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Pool Pools
Bar (BARS)
Thalweg (TLWG)
Floodplain Scour Hole Pools (FSHP)
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Upstream Control Zone
Thermally Exposed Zone
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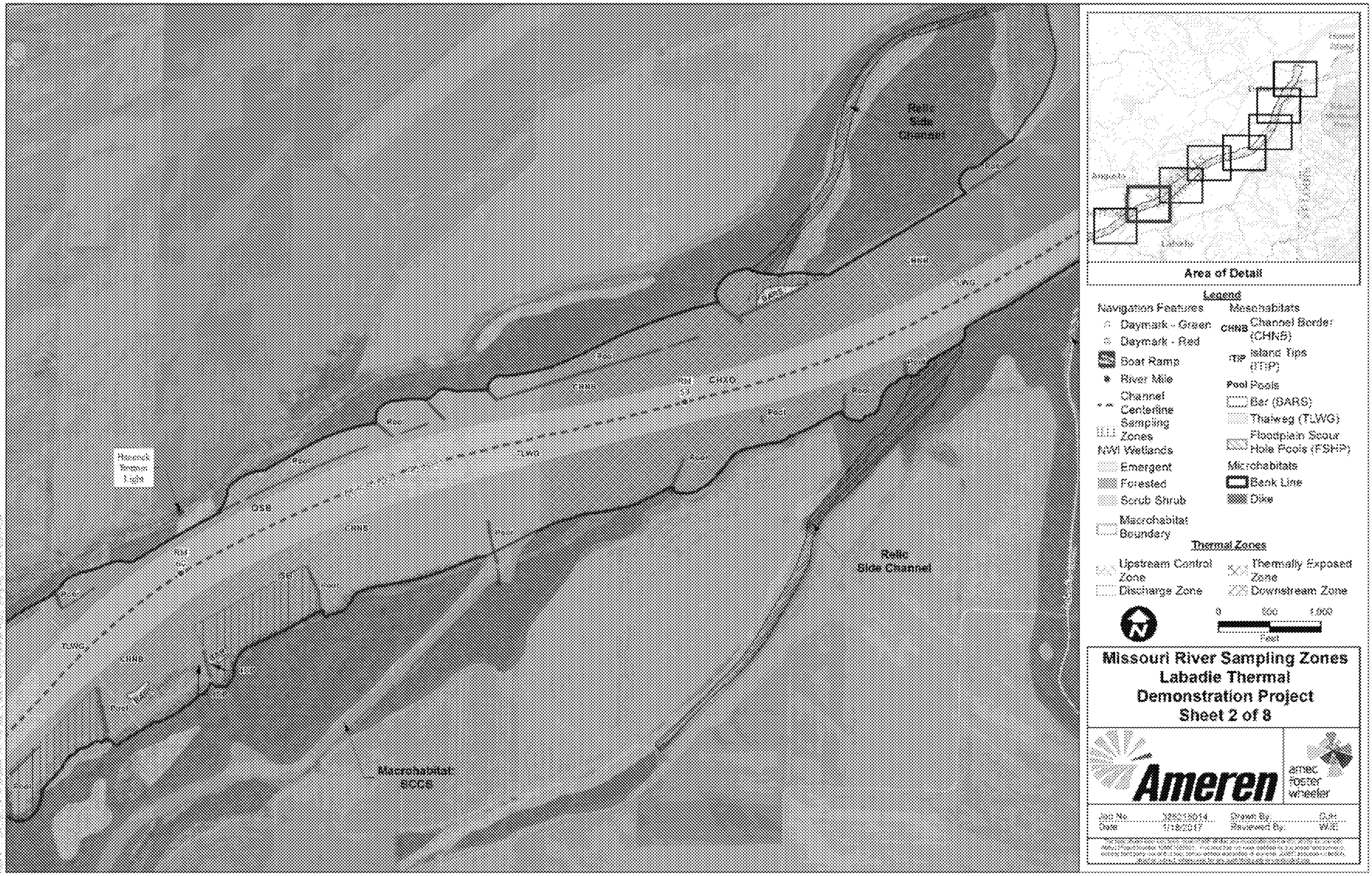
Date: 1/16/2017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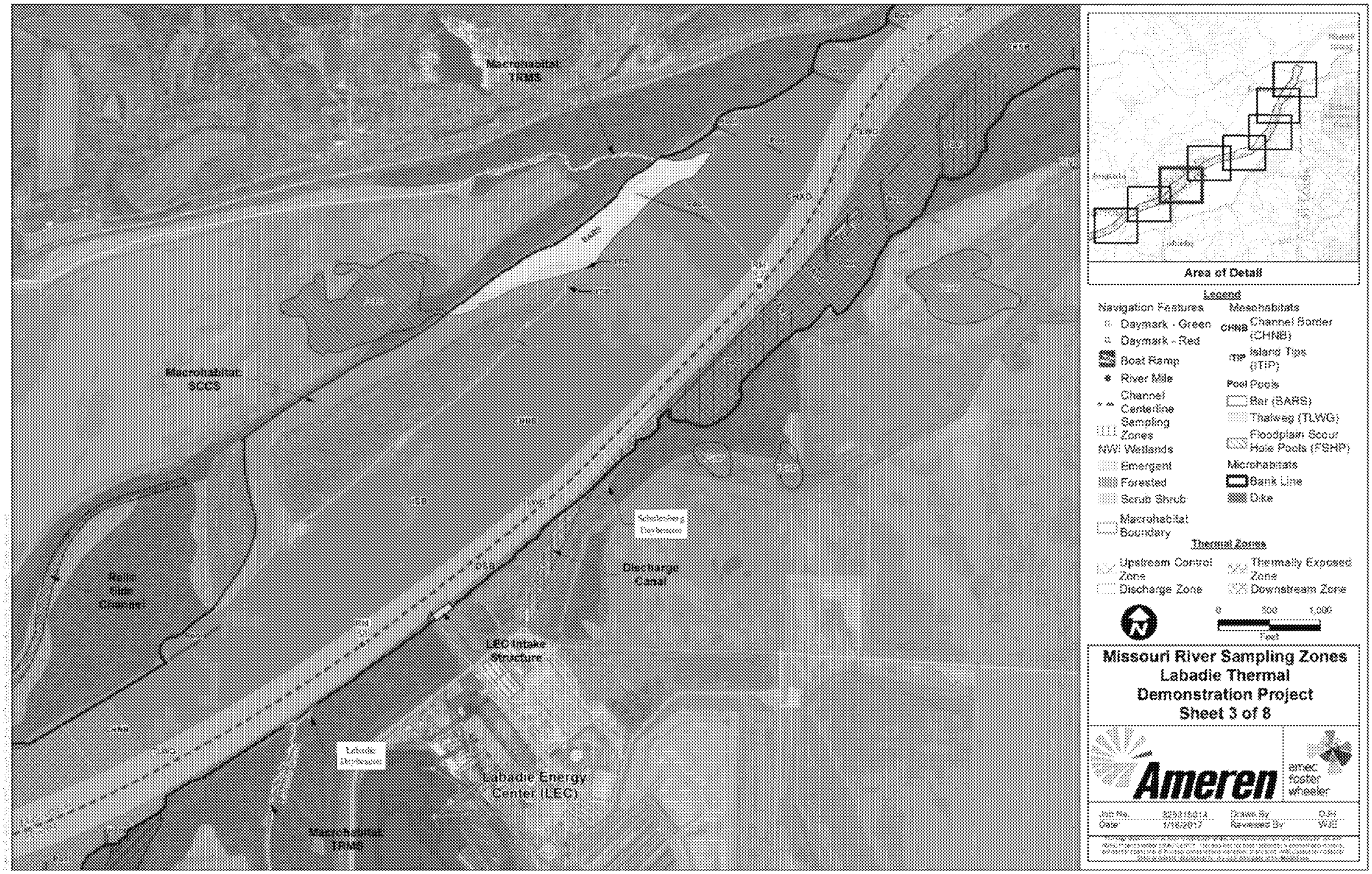
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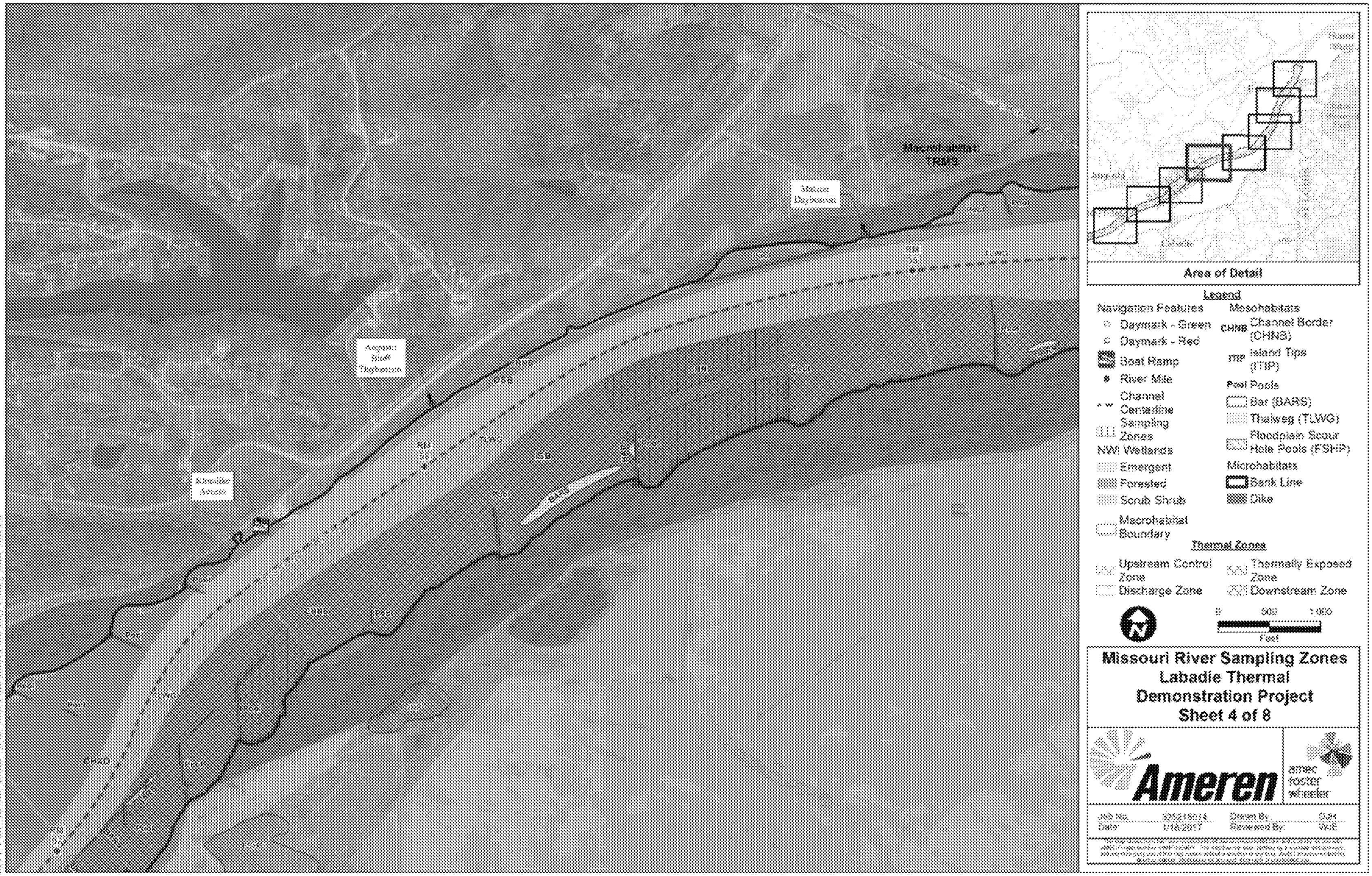

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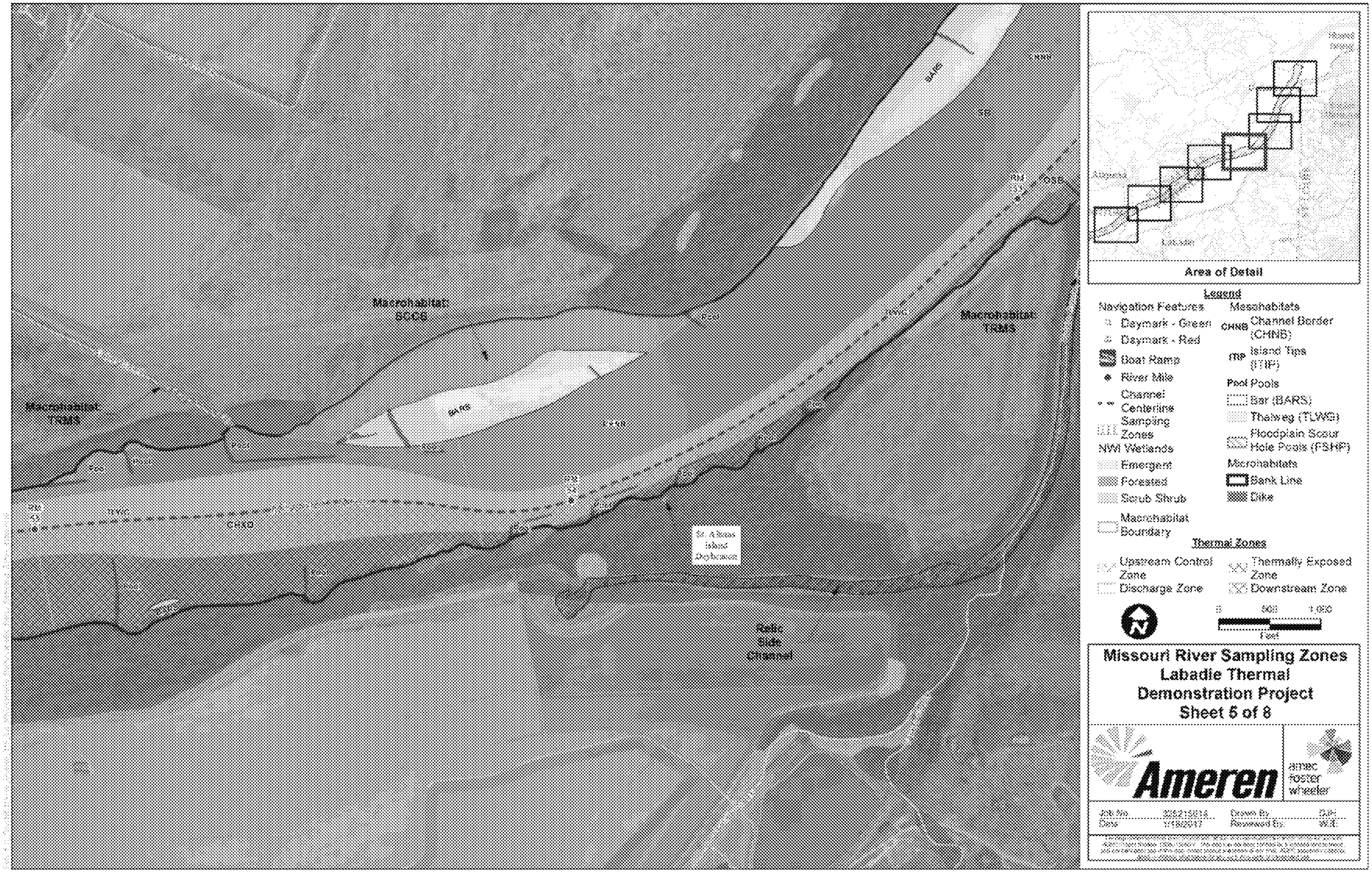
Drawn By:
Reviewed By: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Pool
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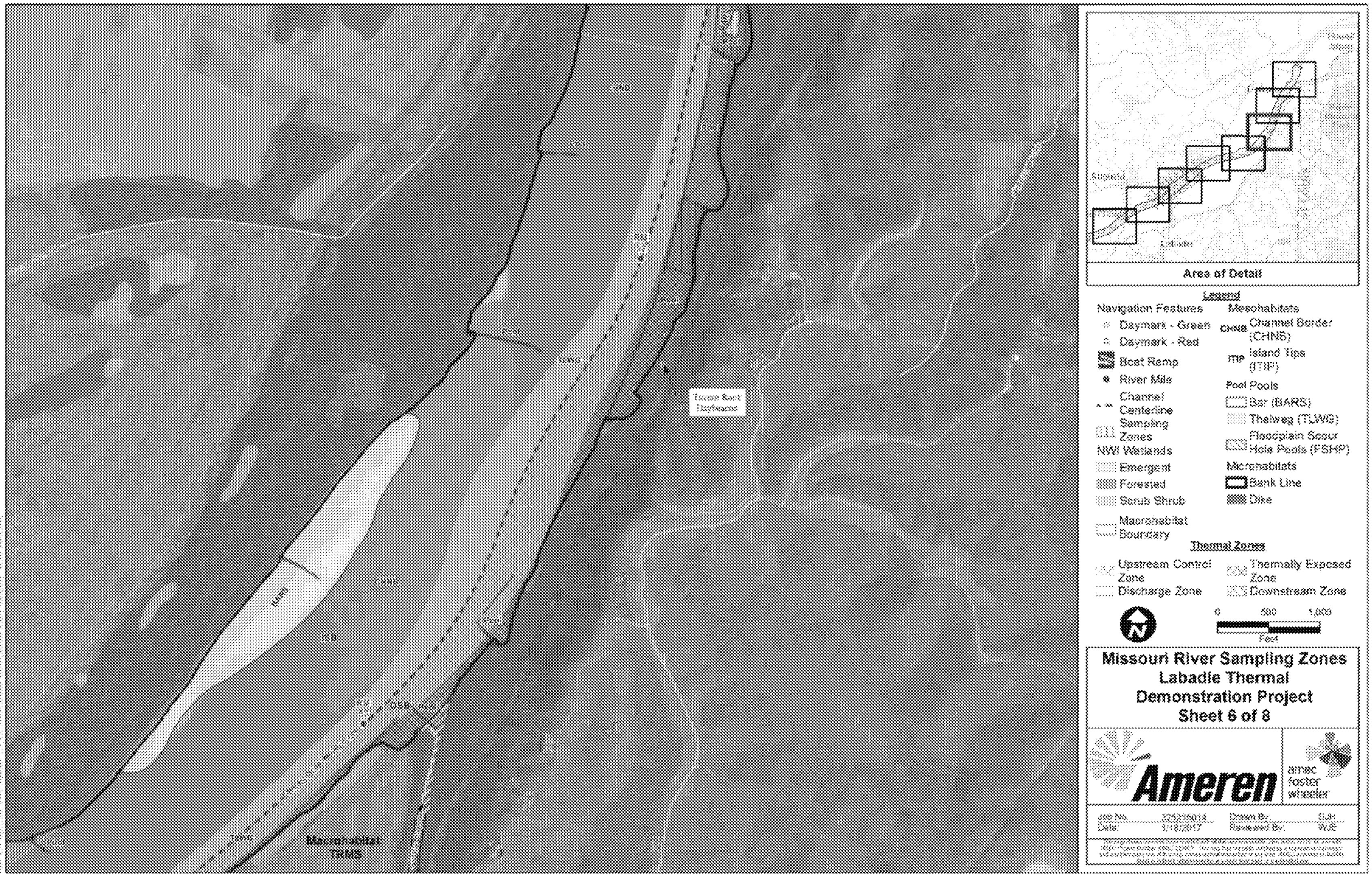
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amec foster wheeler
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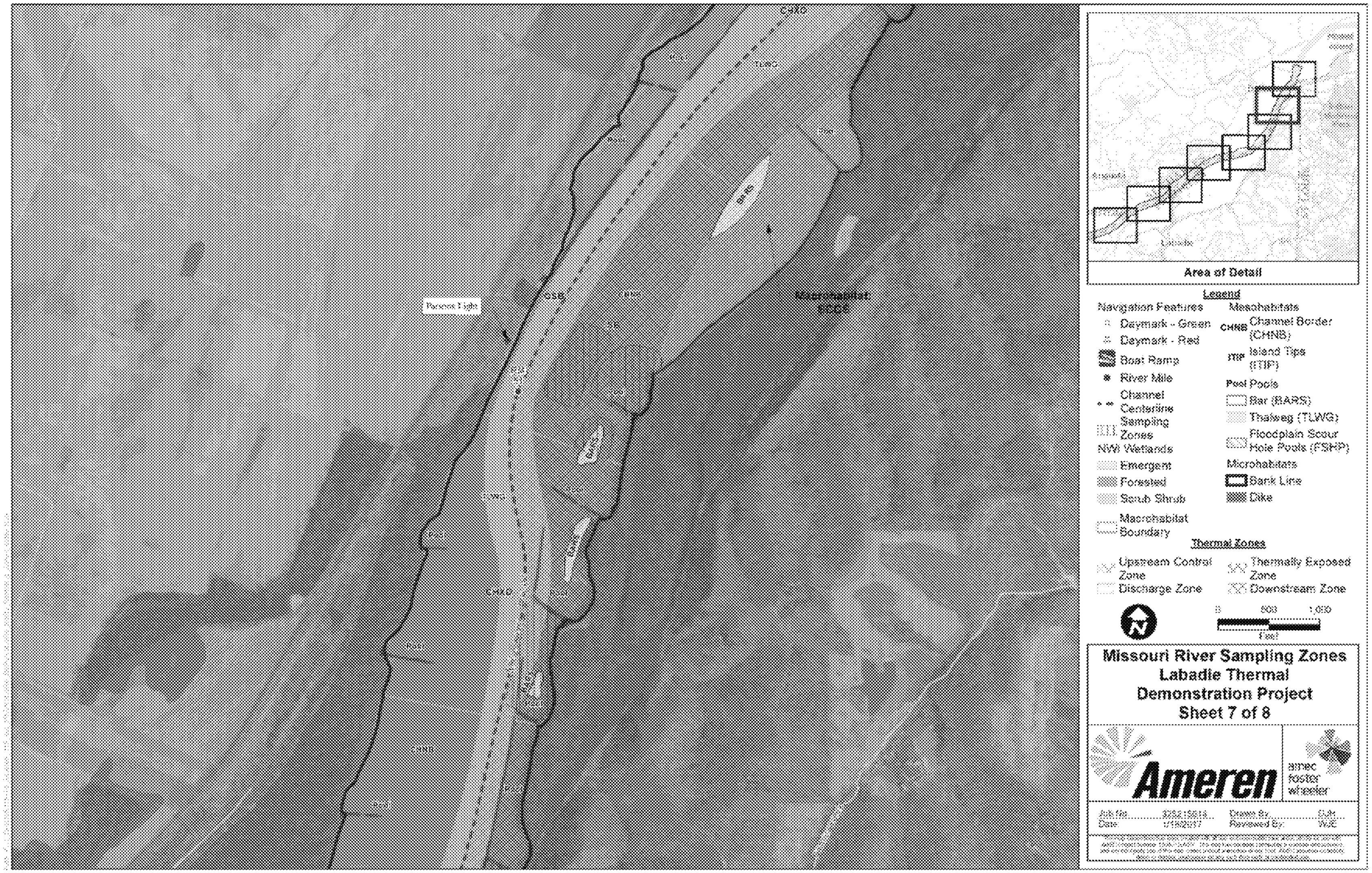
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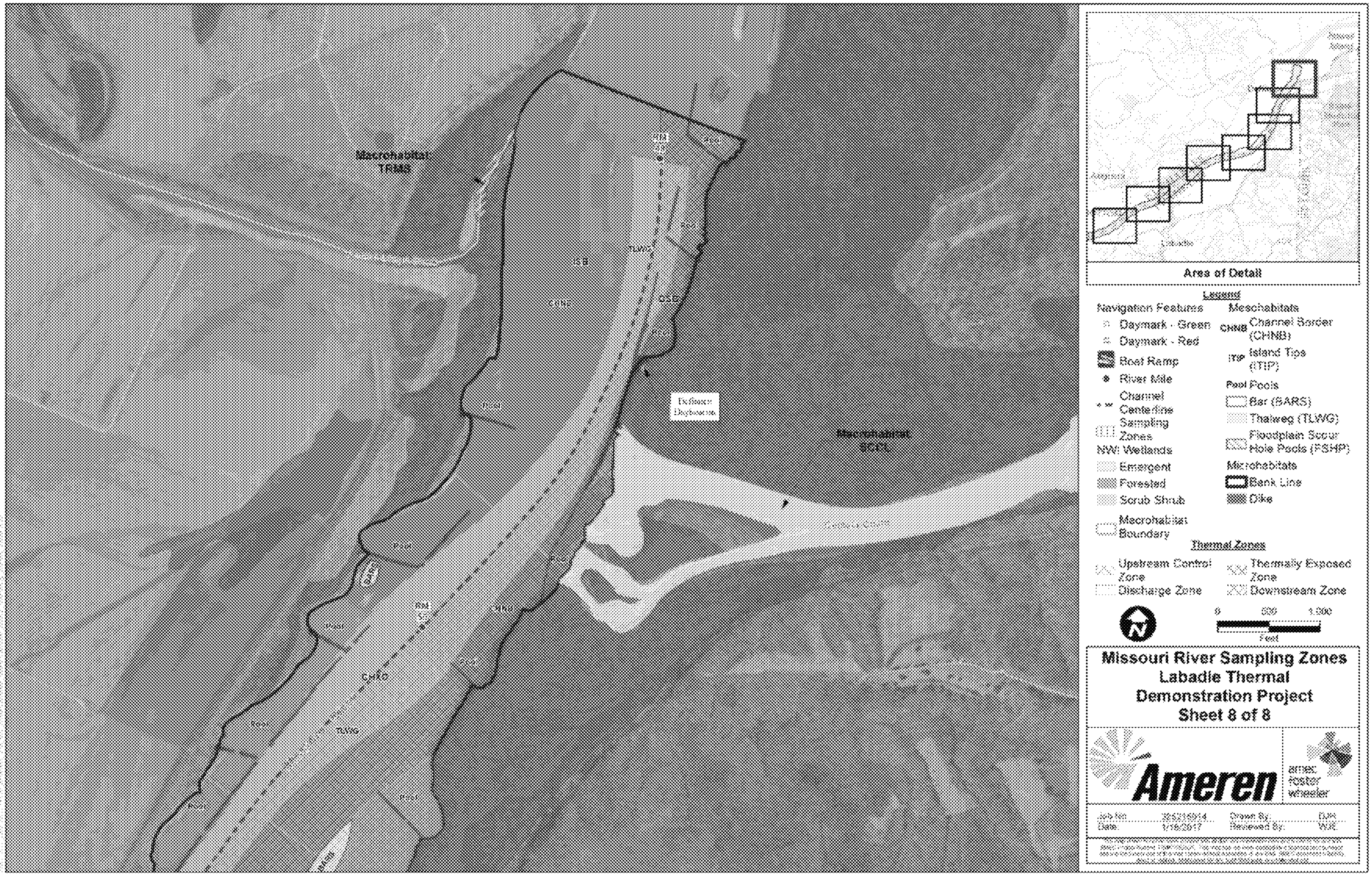
CHXO
TLWG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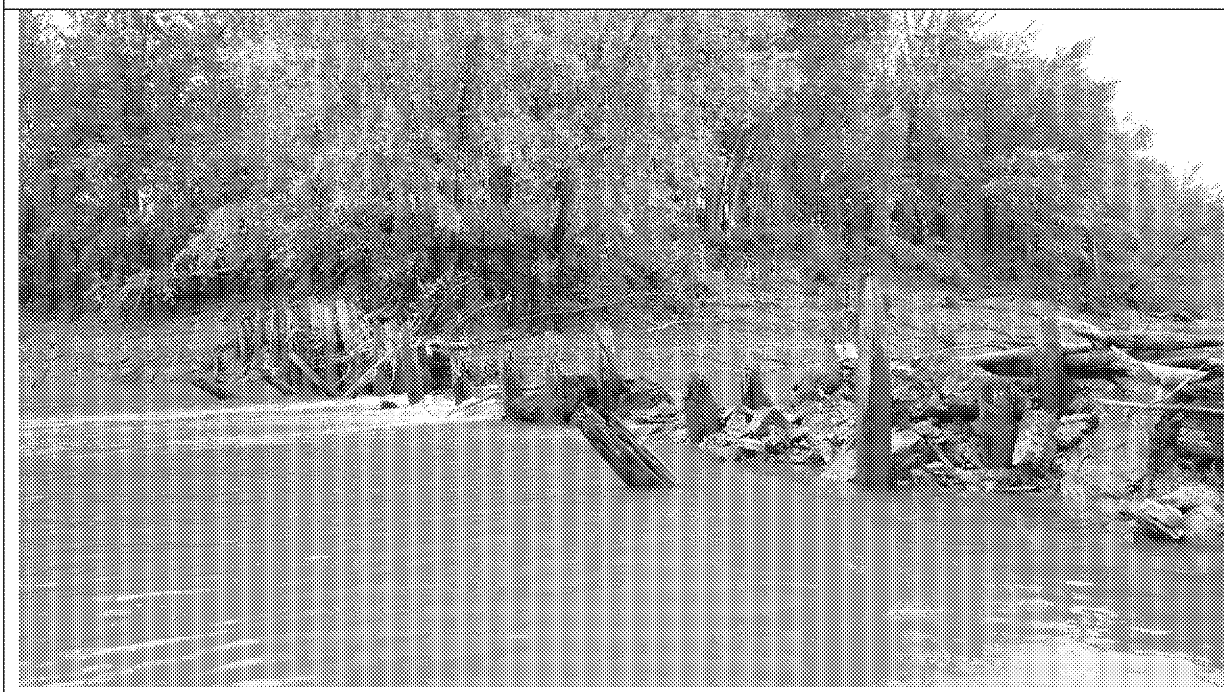
APPENDIX B
Reconnaissance Survey Photo Log

Upstream Control Zone

1. View upstream of inside of second L-dike on outside bend within Upstream Control Zone (approximately RM 61.2).



2. Close-up view of second L-dike on outside bend within Upstream Control Zone (approximately RM 61.2).

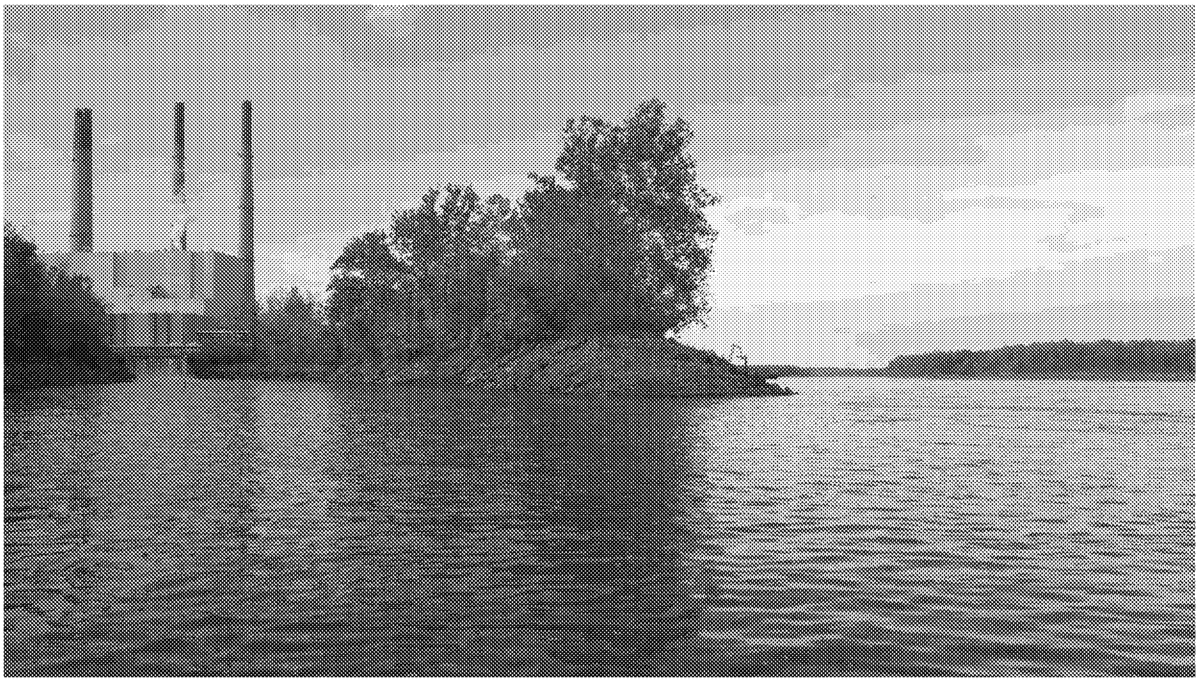
3. Downstream view of shoreline downstream of second L-dike on outside bend within Upstream Control Zone (approximately RM 61.2).

4. View upstream of second L-dike in main channel crossover within Upstream Control Zone (approximately RM 60.5).

5. Close-up view of wing-dike on inside bend within Upstream Control Zone (approximately RM 60).

6. View of sand bar on inside of second L-dike on main channel crossover within Upstream Control Zone (approximately RM 58.75).

Discharge Zone



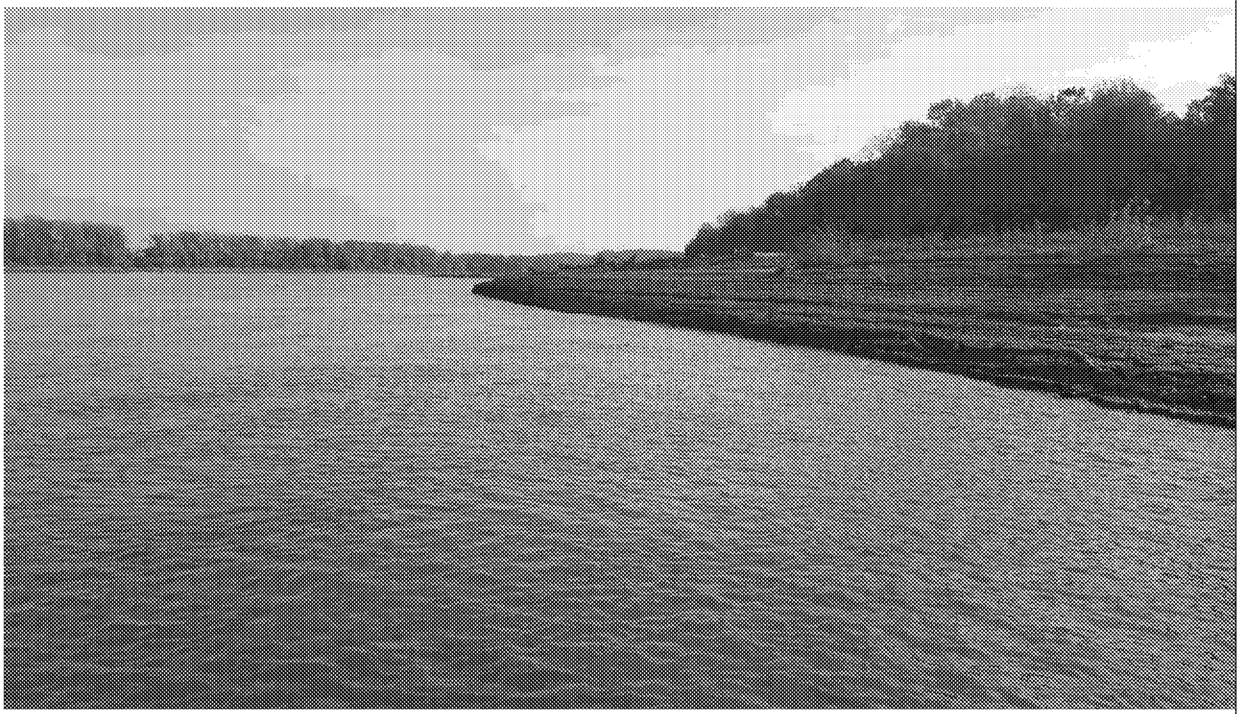
7. View of Labadie Energy Center discharge canal and western point of discharge canal mouth with the Missouri River (mix of mud/clay/rock substrate).

8. Eastern stretch of discharge canal near mouth with the Missouri River (mud/clay substrate).

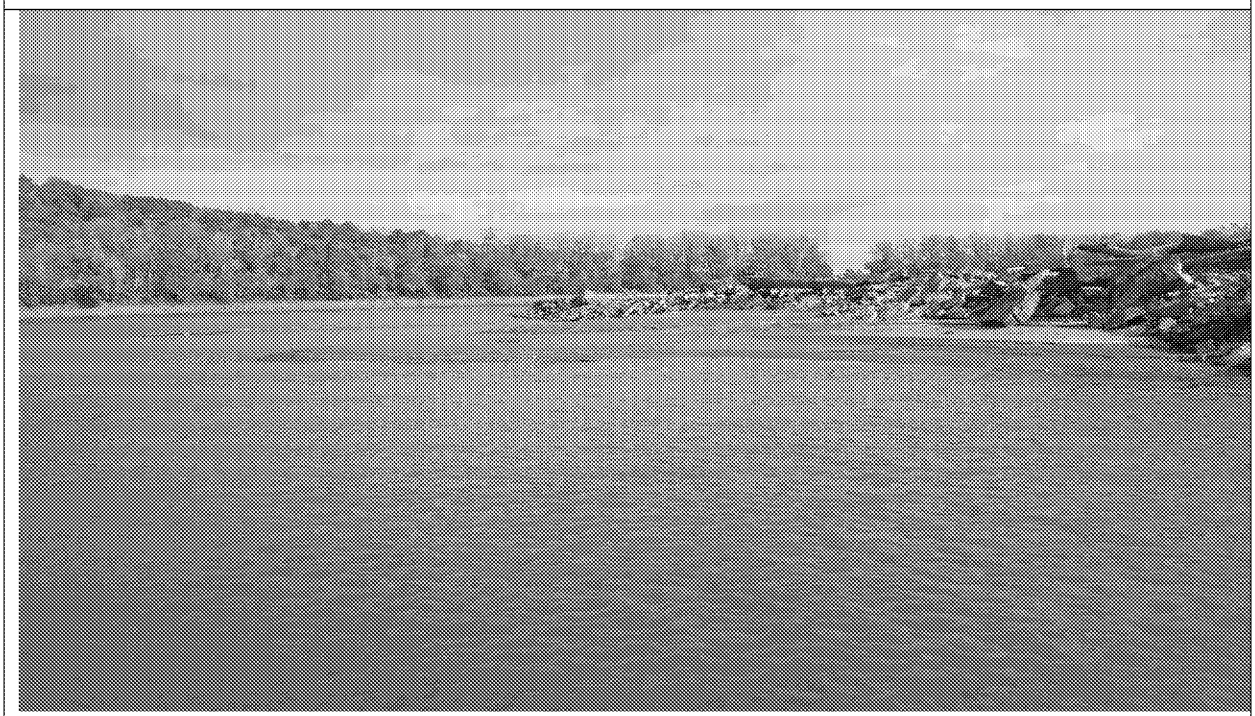
Thermally Exposed Zone

9. First L-dike on outside bend within Thermally Exposed Zone with view of notch.

10. Sand bar on inside corner of second L-dike in main channel crossover within Thermally Exposed Zone.



11. View downstream of bar habitat composed of mud/clay within Thermally Exposed Zone (approximately RM 55.8).



12. View sand bar on upstream side of wing-dike within Thermally Exposed Zone (approximately RM 55.6).

13. Second wing-dike on inside bend within Thermally Exposed Zone (approximately RM 55.6).

14. View of shoreline downstream of second wing-dike on inside bend within Thermally Exposed Zone (approximately RM 55.5).

Downstream Zone

15. View upstream of inside of first L-dike on outside bend within Downstream Zone (approximately RM 52.25).

16. View upstream of first L-dike in channel crossover within Downstream Zone (approximately RM 51.5).

17. View of shoreline downstream of first L-dike in channel crossover within Downstream Zone (approximately RM 51.5).

18. View of bar composed of mud/sand within first L-dike in channel crossover of Downstream Zone (approximately RM 51.5).

19. Downstream view of bar composed of mud/sand downstream of first wing-dike in channel crossover within Downstream Zone (approximately RM 51).

20. View upstream of first wing-dike on inside bend within Downstream Zone (approximately RM 50.9).

21. Close-up view of first wing-dike on inside bend within Downstream Zone (approximately RM 50.9).

AMEREN MISSOURI LABADIE ENERGY CENTER
316(A) STUDY PLAN

ADDENDUM 2
PREDICTIVE BIOTHERMAL ASSESSMENT

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May 2017

TABLE OF CONTENTS

1 INTRODUCTION AND PURPOSE

This Addendum 2 summarizes proposed methodology for conducting a predictive biothermal assessment for the Labadie Energy Center (LEC) Thermal Study. It supplements a general description presented in Section 5.3 of the LEC 316(a) Study Plan dated August 18, 2016. The predictive biothermal assessment, together with the retrospective assessment described in Section 5.2 of Study Plan, will provide a comprehensive assessment of the potential biological effects of exposure on a seasonal basis to the LEC thermal plume, as related to the protection and propagation of a balanced indigenous community (BIC) in the lower Missouri River.

Together, the predictive and retrospective assessments will form a weight-of-evidence approach using several sources of guidance, including:

- USEPA draft guidance manuals (Draft 316(a) Guidance) issued for the implementation of Section 316(a) of the Clean Water Act (CWA) in 1974, 1975, and 1977 (USEPA 1974, 1975, 1977);
- 40 CFR Part 125 Subpart H;
- Professional practice in prior Section 316(a) assessments at other generating stations; and
- Guidelines for Ecological Risk Assessment (ERA Guidance) recommending approaches and criteria for assessing impacts from chemical, physical, or biological stressors (USEPA 1998).

The LEC has been continuously operating since its four generating units were placed in service between 1970 and 1973. The continuous operation of LEC over the past 46+ years would suggest that a Type I, retrospective demonstration of No Prior Appreciable Harm (NPAH), as described in Section 5.2 of the Study Plan, will constitute the best evidence of thermal effects of the LEC discharge on the aquatic community in its vicinity and ultimately the lower Missouri River.

The greatest utility of a Type II predictive assessment, including the assessment of the relative vulnerability of biotic categories (Section 5.1 of the Study Plan), is its application to facilities in the planning stage or at sites where there is an insufficient period of operation to manifest all thermal effects. However, a predictive assessment may provide information and insight into the population and community dynamics underlying the data collected from field surveys (Section 4 of the plan) or on species and life stages not collected but suspected to be present in the study area.

The LEC 316(a) studies will utilize a retrospective assessment to evaluate the endpoint of NPAH for both benthic macroinvertebrates and fish. The predictive assessment outlined in this addendum will be conducted to supplement the retrospective assessment for selected representative important species (RIS) of fish.

The predictive assessment will utilize information derived from modeling of the LEC thermal plume, available literature on the thermal tolerance of selected species, and the seasonality of occurrence by life stage as demonstrated by catch statistics from the field sampling and pertinent literature sources or other surveys of the lower Missouri River. Section 2 below briefly describes the mathematical model selected to simulate the spatial characteristics of the LEC thermal plume under varying environmental and operational scenarios. Section 3 proposes the elements of an assessment of potential thermal effects on individual fish species and their life stages residing within the influence of the modeled thermal plume. Section 4 states where the predictive assessment results will be reported and interpreted.

2 HYDROTHERMAL MODELING

2.1 MODEL SELECTION

In support of the predictive biothermal assessment, a state-of-the-art, dynamic hydrothermal model will be used to simulate the spatial extent of the LEC's thermal plume, depicted as an equilibrium state under a specified scenario of river and plant operation conditions. The FLOW-3D computational fluid dynamics model (Flow Science 2016) was selected for modeling the three-dimensional mixing of the LEC thermal discharge with the Missouri River. This model was deemed appropriate for this application because of its ability to simulate both near-field and far-field mixing and to accommodate complex river features such as variable bathymetry, bars, islands, and dikes that are present in the Missouri River. It previously has been used in evaluating compliance with Missouri thermal water quality standards (Kleinfelder 2016) where it is described in more detail, including validation procedures. It also has been used to support the selection of sampling sites for annual biological monitoring for the retrospective biothermal assessment, as described in the Study Plan and its Addendum 1, Habitat Characterization and Sampling Site Selection.

For the predictive assessment, the model domain (spatial extent of the computational grid) will extend from approximately 0.75 river miles upstream of the facility discharge to a point approximately 8 river miles downstream of the discharge. Two overlapping numerical meshes with different resolutions will be used: a nested grid mesh with fine spacing (15 feet by 15 feet) for higher resolution near the discharge outfall and a coarser mesh (30 feet by 30 feet) away from the discharge outfall. The vertical resolution will be 4 feet for both grid meshes.

2.2 MODEL SCENARIOS

Multiple scenarios representing varying inputs of boundary conditions (i.e., river flow rate and river temperature) and plant operating conditions (i.e., discharge flow rate and discharge temperature) will be modeled to characterize plume temperatures to which resident organisms would be exposed. The scenarios will be selected with the objective of representing reasonable "worst case" (maximum temperature elevation) and typical conditions on a seasonal basis, relying on statistical analysis of historical records of the LEC operation and river flow and temperature.

Preliminary modeling (Kleinfelder 2016) has indicated that plume temperature exposure likely would be greatest during periods of low river discharge, most importantly during summer and winter months. These two seasons are expected to be targeted by the predictive biothermal assessment. Besides river flow and temperature, the model input variables of plant discharge temperature and discharge flow rate will be evaluated to determine operating conditions that most effect elevated plume temperatures.

3 ASSESSMENT METHODS

3.1 REPRESENTATIVE IMPORTANT SPECIES

USEPA's 1977 Draft 316(a) Guidance recognizes that it is impractical to study and assess in detail every species at a site. Therefore, it is necessary to select a smaller group designated as RIS to be representative of the balanced indigenous community. As stated in USEPA's 1977 Draft 316(a) Guidance, RIS would include species that are:

- representative, in terms of their biological requirements, of a balanced indigenous community of fish, shellfish, and wildlife;
- commercially and recreationally valuable;
- threatened or endangered;
- critical to the structure and function of the ecosystem (e.g., habitat formers);
- potentially capable of becoming localized nuisance species; and
- necessary in the food chain for the well-being of species determined above.

Other considerations for RIS selection include the extent of the species' involvement with the thermal plume, their thermal sensitivity, and the quantity and quality of information available for the assessment, such as data on thermal tolerance.

Another consideration is the seasonal occurrence and abundance of prospective species within the area potentially influenced by the LEC thermal plume. While many or most fish species in the lower Missouri River may be year-round residents within the area, some are more transient, using the area for adult spawning migrations, dispersal of young to habitats more suitable for the species, or refuge from natural environmental conditions (e.g., high flows or non-preferred water temperatures). For fish species, the results of catch data collected during the monthly surveys for the retrospective assessment will provide an additional basis for RIS selection.

The final selection of RIS for the predictive biothermal assessment will be made in consultation with the MDNR. To the extent that thermal tolerance data are available and seasonal presence in the study area is indicated, all life stages for the RIS (embryonic, larval, juvenile, and adult) will be included in the analysis. A preliminary list of RIS and the reason for inclusion is as follows.

Species	**Reason for Inclusion**
Pallid sturgeon *Scaphirhynchus albus*	endangered species
Bighead/silver carp *Hypophthalmichthys* sp.	nuisance species
Gizzard shad *Dorosoma cepedianum*	food chain species
Walleye/sauger *Sander* sp.	thermally sensitive recreational species
Channel catfish *Ictalurus punctatus*	commercial/recreational species
Emerald shiner *Notropis atherinoides*	food chain species
White crappie *Pomoxis annularis*	thermally sensitive recreational species
Largemouth bass *Micropterus salmoides*	commercial/recreational species
Shorthead redhorse *Moxostoma macrolepidotum*	thermally sensitive species

3.2 RIS EVALUATION

As recommended in the USEPA Draft 316(a) Guidance, the potential effects of the thermal discharge on RIS to be evaluated will include:

- mortality from excess heat,
- mortality from cold shock,
- habitat exclusion,
- blockage of migration, and
- reduced growth or reproductive success.

The nature and likelihood of thermal effects will be characterized by evaluating the habitat preferences, seasonal occurrence, and temperature requirements or limits of each species and life stage to thermal exposures potentially resulting from the LEC's operations, as determined from the hydrothermal modeling.

River temperature sampling surveys and preliminary model runs have indicated that the thermal plume becomes entrained along the right descending shoreline, which in the study area includes wing dikes and L-dikes, as well as open shoreline (see Addendum 1). With this in mind, the evaluation will include fish species that utilize channel margin and nearshore habitats (particularly dike fields) in addition to the river's main channel.

The predictive analyses will identify the nature and seasonal timing of potential thermal effects on each RIS and life stage. The spatial extent of these potential effects will be characterized by estimating the dimensions of the water body (e.g., volume, cross-sectional area) occupied by temperatures that might limit important biological activities.

Mortality from excess heat (heat shock) could include all life stages whose presence in the area would be expected. The elapsed time of exposure to potentially lethal temperatures will be evaluated for RIS whose eggs and larvae freely drift in the river current and for RIS that depend on habitat more protected from the river currents for spawning and early life stage development.

The potential for mortality from cold shock will be evaluated for species utilizing the thermal plume to achieve their preferred temperatures but could suffer acute mortality if the thermal plume were dissipated by abrupt cessation of thermal discharge from the LEC operating units. Laboratory-derived data for cold shock is sparse for the RIS but will be used for this evaluation as available.

Juvenile and adult fish, with their greater mobility than earlier life stages, may vacate water temperatures exceeding their preference and thus be excluded temporarily from the otherwise suitable habitat. Laboratory-derived avoidance and preference temperatures available in the literature will be used to quantify the amount of excluded habitat.

Some fish species utilize the lower Missouri River for seasonal migrations to and from spawning areas or areas on which they rely for forage or optimal habitat. The predictive assessment will evaluate the possibility of blockage of these migrations by thermal plume temperatures equaling or exceeding available laboratory-derived avoidance temperature data for the species. To this end, the minimum cross-sectional area providing passage for the migrating species will be quantified as a percentage of the river's overall cross-section along a transect corresponding to the greatest influence of the plume.

Lastly, elevated plume temperatures have the potential of affecting the location and possibly the timing of fish spawning, as well as the survival, development, and growth of their spawn. The potential for these thermal effects will be evaluated to the extent that required thermal tolerance data are available for individual species and early life stages. Emphasis will be placed on riverine habitats that are utilized as spawning and rearing areas, including shallow water habitats and those with shoreline structures such as dikes or natural cover types. The season, location, and size of potentially affected habitat areas will be described.

4 REPORTING

The results of the predictive biothermal assessment will be incorporated into the §316(a) variance demonstration and will be combined and interpreted along with the results of the retrospective assessment described in Section 5.2 of Study Plan. Together, these two assessments will be the basis for a master rationale determining whether the LEC thermal discharge is protective of a balanced indigenous community in the lower Missouri River.

5 REFERENCES CITED

Kleinfelder Associates (Kleinfelder). 2016. Thermal Plume Modeling and NPDES Permit Effluent Limitations for the Ameren Labadie Energy Center Missouri State Operating Permit No. MO-0004812.

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AMEREN MISSOURI LABADIE ENERGY CENTER
316(a) STUDY PLAN

ADDENDUM 3
SUMMARY OF REVISIONS TO THE INITIAL STUDY PLAN

DRAFT

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May 2017

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1 INTRODUCTION AND PURPOSE

This addendum summarizes changes and adjustments to the original Labadie Energy Center (LEC) 316(a) Study Plan (the plan) resulting from work conducted subsequent to the initial plan submittal. Phase I of the plan that included the preliminary hydrothermal modeling, habitat characterization, and sample site selection has been completed and is presented in Addendum 1 to the Labadie 316(a) Study Plan. While the results of this work did not require major changes to the study approach or the main components of the plan (i.e., hydrothermal modeling, biological monitoring studies), they did necessitate revisions to some of the details associated with the biological monitoring studies. The revisions to the biological monitoring studies include:

- the number of sampling zones,
- the number of riverine habitat types present in the study area,
- types of gear proposed for sample collection, and
- number of samples per gear type and habitat type.

There were no revisions to Sections 1, 3, and 6 of the Study Plan. Section 2 presented an overview of the study and sampling approach. Therefore, the changes described below would also apply to the corresponding sections of Section 2. The only change to Section 5 of the original Study Plan, which presented the biothermal assessments, is that Ameren has decided to proceed with conducting the predictive assessment (Addendum 2 to the Labadie 316(a) study plan).

The remainder of this addendum highlights the changes made to the original Labadie 316(a) Study Plan that was submitted to the MDNR on August 22, 2016 and provides a brief rationale for each change.

2 REVISIONS TO THE ORIGINAL LABADIE 316(A) STUDY PLAN

Subsequent to the submittal of the initial Labadie 316(a) Study Plan, Ameren completed work on the Phase I studies described in Section 4.1, Phase I of the plan. Phase I studies included preliminary hydrothermal modeling and habitat characterization for the anticipated study area and resulted in the selection of sample collection sites for the biological monitoring studies. The sampling zones, riverine habitat types, sampling gear, and sampling sites described in the original study plan were based on anticipated thermal plume distribution and habitat types. The completion of Phase I resulted in a more accurate description of the expected thermal plume distribution and habitat types within the study area, thus allowing refinements to the fish and benthic macroinvertebrate surveys which are described below.

In addition to the refinements for the fish and benthic macroinvertebrate surveys, continuous temperature monitoring has been added to the study plan for sampling locations in the discharge, thermally exposed, and downstream zones. Continuous temperature monitoring will provide data with which to evaluate the short-term changes in temperature regime within each habitat type and zone. ONSET HOBO continuous temperature monitors will be set 1 foot below the surface and 1 foot above the bottom in each habitat type (except channel border habitats due to the swift current) in each zone. Temperature monitors will be set at 2 locations within the discharge zone – one in the discharge canal and one along the bank downstream of the mouth of the discharge canal. Temperature will be recorded every 15 minutes and temperature monitors will be checked and data downloaded monthly. During periods of high river flow and debris loading, monitors may be removed until river conditions allow the monitors to be reset.

2.1 FISH SURVEYS – SITE SELECTION

The following describes revisions to survey details in Section 4.2.1, Fish Surveys of the original Study Plan for sample site selection.

Addition of fourth sampling zone

A discharge zone was added to the study area and includes the discharge canal downstream to the first wing dike. This area has been sampled historically and, based on the preliminary hydrothermal modeling, experiences a thermal exposure distinct from other zones. The four sampling zones that comprise the LEC 316(a) study area are now:

1. An upstream control zone unaffected by the LEC intake or discharge (RM 58.5 – RM 62),
2. A discharge zone encompassing the area of highest potential exposure to the thermal discharge (RM 57.5 – RM 57.25)
3. A thermally exposed zone where any potential effects from thermal discharge would be expected if present (RM 57.25 – RM 52), and
4. A downstream zone which potentially could experience minor and transient exposure to the thermal discharge (RM 52 – RM 50).

Data collected from the discharge zone will be compared to available historical data for the same area. Therefore, fish and benthic macroinvertebrate sampling will be conducted using only the same sampling methods as historical studies – electrofishing for fish and a Ponar dredge and Hester-Dendy samplers for benthic macroinvertebrates. Sampling in the other three zones will be stratified by habitat and use multiple gear types to allow a comparison of fish and benthic macroinvertebrate communities among the upstream control, thermally exposed, and downstream zones.

Temperature defining extent of thermally exposed zone

A temperature 5°F above the ambient river water temperature was used to define the thermally exposed zone in the original plan. The thermally exposed zone is now based upon a temperature 3°F above the ambient temperature. A temperature of 3°F above ambient is considered to exceed natural daily water temperature variations[1] and would approximate the 90°F isotherm (the Missouri water quality standard for maximum temperature) at the highest modeled temperature of 87°F.

Habitat types sampled within each zone

The original plan assumed there would be three primary habitat types sampled within each sampling zone — channel border, wing-dike or L-dike field, and main-channel/thalweg (inside bend or outside bend). Based upon the preliminary hydrothermal modeling and habitat characterization conducted in Phase I studies, the following six habitat types will be sampled in each of the three primary zones (upstream control, thermally exposed, and downstream):

1. Inside bend channel border;
2. Outside bend L-dike/pool
3. Channel crossover L-dike/pool
4. Inside bend W-dike/pool
5. Inside bend W-dike/bar
6. Channel crossover L-dike/bar

2.2 FISH SURVEYS – SAMPLE COLLECTION

The following describes revisions to survey details in Section 4.2.1, Fish Surveys of the original Study Plan for sample collection methods.

Addition of hoop nets

The original plan specified the use of four gear types for conducting the fisheries sampling — electrofishing, mini-Missouri trawl, seine, and plankton net. Hoop nets are added as a fifth sampling gear type. One hoop net will be deployed per habitat type per zone (Table 2-1) for a total duration of 48 hours per event. Nets will be checked and reset after 24 hours.

Specification of sampling gear by habitat type

Based on the three habitat types presumed to be present in the original plan, channel border habitats were to be sampled using the mini-Missouri trawl and electrofishing; dike field habitats were to be sampled using the same two gears plus a plankton net and bag seine; and the channel/thalweg habitat would be sampled using the mini-Missouri trawl. Table 2-1 lists the revised habitat types and sampling gear that will be used to sample each habitat type.

Night sampling eliminated

Day and night sampling was proposed for all gear types in the original plan. Night sampling was eliminated in the revised plan primarily because of crew safety concerns. Hoop nets will be sampled using an overnight set in lieu of mini-Missouri trawl night sampling.

Number of mini-Missouri trawls per habitat type

The original plan specified that one trawl sample of an approximate duration of 3 to 5 minutes would be collected in each habitat type in each zone. The plan was revised to include three trawls

[1]Conservatively based on a typical daily water temperature range of 1-2°F recorded at USGS gage 06935550, upstream of the LEC cooling water discharge outfall

each of an approximate duration of 2 to 5 minutes in each habitat type in each zone. The 3 trawls will be composited to yield one trawl sample per habitat type per zone.

Number of ichthyoplankton tows per habitat type

The original study plan stated that two ichthyoplankton tows would be collected in each of three habitat types in each primary sampling zone during each sampling event. The number of ichthyoplankton tows per habitat type per sampling zone (upstream control, thermally exposed, and downstream) per event has been revised to one tow in each of the six habitat types listed above in Section 2.1.

Ichthyoplankton net and tow duration

A 1-meter plankton net was specified for ichthyoplankton sampled collection in the original plan and tow duration was estimated between 3 and 5 minutes each. A one-half meter plankton net with 500-micron mesh will now be used in lieu of the 1-meter net. As a result of the smaller diameter net being used, the tow duration will be extended to between 5 and 10 minutes to yield a 50-cubic meter sample.

Number of seine hauls per habitat type

Two seine hauls in a single habitat type (dike field) per zone were specified in the original plan. The number of seine hauls has been revised to one to two per habitat type per zone (upstream control, thermally exposed, and downstream) per event. In addition, seining will now be conducted in two habitat types per zone (Table 2-1).

2.3 BENTHIC MACROINVERTEBRATE AND SHELLFISH SURVEYS – SITE SELECTION

The revisions that were made to the fish surveys site selection section in the original plan regarding the number of sampling zones and the temperature used to delineate the thermally exposed zone described in Section 2.1 above also were made to the corresponding sections of the benthic macroinvertebrate and shellfish surveys section of the original plan.

Selection of habitat types for sampling

Three habitat types have been selected for benthic macroinvertebrate and shellfish sampling in each of the three primary sampling zones (upstream control, thermally exposed, and downstream):

- Outside bend L-dike/pool
- Channel crossover L-dike/pool
- Inside bend W-dike/pool

In addition, benthic macroinvertebrate samples will be collected from the discharge zone.

2.4 BENTHIC MACROINVERTEBRATE AND SHELLFISH SURVEYS – SAMPLE COLLECTION

The following describes revisions to benthic macroinvertebrate and shellfish survey details in Section 4.2.2 of the original Study Plan for sample collection methods.

Grain size samples

The original plan specified that a separate ponar grab sample would be collected from each sample site for a qualitative grain size analysis. In the revised study plan, the qualitative grain size analysis will be conducted on the composite sample comprised of the three ponar grabs in each habitat type in each zone.

Hester-Dendy sampler array placement

In the original plan, Hester-Dendy sampler arrays were to be placed at three locations within each sample site in each zone. Based on the additional habitat types identified, Hester-Dendy arrays will be placed at two locations within each habitat type in each zone.

Table 2-1. Proposed Sampling Locations and Gear Types for Macrohabitats and Mesohabitats within each Sampling Zone

Sampling Zone	Macrohabitat	Mesohabitat	Approximate River Mile	Electrofishing	IP Tows	Bag Seine	Benthos*	Hoop Net	MO-trawl
Upstream Control Zone	Inside Bend	Channel Border	61.5						✓
	Outside Bend	L-dike/Pool	61.2	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Pool	60.5	✓	✓		✓	✓	✓
	Inside Bend	W-dike/Pool	60	✓	✓		✓	✓	✓
	Inside Bend	W-dike/Bar	60			✓			
	Main Channel Crossover	L-dike/Bar	58.75			✓			
Discharge Zone	NA	NA	57.5	✓			✓		
Thermally Exposed Zone	Outside Bend	L-dike/Pool	57.25	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Bar	56.8			✓			
	Main Channel Crossover	L-dike/Pool	56.6	✓	✓		✓	✓	✓
	Inside Bend	Channel Border	56.25						✓
	Inside Bend	W-dike/Bar	55.6			✓			
	Inside Bend	W-dike/Pool	55.6	✓	✓		✓	✓	✓
Downstream Zone	Outside Bend	L-dike/Pool	52.25	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Pool	51.5	✓	✓		✓	✓	✓
	Main Channel Crossover	L-dike/Bar	51.5			✓			
	Inside Bend	W-dike/Bar	51			✓			
	Inside Bend	W-dike/Pool	50.9	✓	✓		✓	✓	✓
	Inside Bend	Channel Border	50.75						✓

Note: Benthos sampling includes Ponar and Hester-Dendy samplers

3 PREDICTIVE BIOTHERMAL ASSESSMENT

In the original study plan, conducting a predictive biothermal assessment was presented as a potential option pending the outcome of the biological monitoring studies, retrospective assessment, and need for a 316(a) variance request. A predictive biothermal assessment will be conducted to supplement the retrospective assessment and support a request for a 316(a) variance. The predictive biothermal assessment approach is described in Addendum 2 to the Labadie 316(a) Study Plan.

Missouri Department of NATURAL RESOURCES dnr.mo.gov
Eric R. Greitens, Governor Carol S. Comer, Director

JUL 13 2017

Mr. Craig J. Giesmann, Water Quality Manager
Ameren Missouri
P.O. Box 66149, MC 602
St. Louis, MO 63366-6149

RE: 316(a) Thermal Discharge Monitoring Plan Approval for Ameren Labadie Energy Center, Franklin County, MO-0004812

Dear Mr. Giesmann:

The Missouri Department of Natural Resources' Water Protection Program and the Environmental Services Program have reviewed Ameren's Thermal Discharge Monitoring Plan received May 3, 2016, and revised August 24, 2016, and May 30, 2017. The department has determined each comment addressed concerns previously identified on June 8, 2016. The Thermal Discharge Monitoring Plan is approved.

The department provides the following recommendations for Ameren's consideration that may clarify and improve understanding on Ameren's sampling plans but are not required.

1. The 0.25 mile "discharge zone" that includes the canal leading from the LEC to the Missouri River is described in Study Plan Addendum 1 and Addendum 3. It would be beneficial to include language stating that only electrofishing and macroinvertebrate (ponar and Hester-Dendy) sampling will be conducted in this zone at the point in the document where the new zone is introduced. This detail is presented in Table 4-1 in Addendum 1 and Table 2-1 in Addendum 3, but if it was explained along with the introduction of this new sampling zone (end of Section 2.1 in Addendum 1 and Section 2.1 in Addendum 3 under *Addition of fourth sampling zone*), any confusion would be avoided. It should also be pointed out that this discharge zone is not one of the "three primary zones (upstream control, thermally exposed, and downstream)." It appears that a more diverse set of samples will be collected among the three primary zones, and this should be pointed out. In Table 3-1 of Addendum 1 it would be helpful to have some explanation (if only a footnote) as to why the discharge zone was excluded.

2. In Section 2.2 of Addendum 3 (Fish Surveys—Sample Collection) the subsection entitled *Addition of continuous monitoring* is included. Since the information contained in this subsection does not relate to fish sampling, it probably should be a separate section.

Thank you for working with the department in the review and response to comments on the monitoring plan. If you have any questions about our decision, please contact Ms. Leasue Meyers by phone at 573-751-7906, by email at leasue.meyers@dnr.mo.gov , or by mail at the Department of Natural Resources, Water Protection Program, P.O. Box 176, Jefferson City, MO 65102-0176.

Sincerely,

WATER PROTECTION PROGRAM

Chris Wieberg, Chief
Operating Permits Section

CW:lms

c: Mr. John Dunn, US EPA Region VII
Mr. Sam McCord, Water Protection Program
Mr. Dave Michaelson, Environmental Services Program
Mr. Michael Smallwood, Ameren Environmental Services
File Copy

APPENDIX B
RETROSPECTIVE ASSESSMENT TABLES

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B. RETROSPECTIVE ASSESSEMENT SUPPORTIVE MATERIAL

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Table B-1 Species composition (numbers caught and weight in kg) of fish sampled with bag seine at the LEC in 2017-2018, by zone.

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight
1	Red shiner	2972	0.281	NS	NS	NS	Red shiner	1092	0.367	Red shiner	1155	0.351
2	Channel shiner	848	0.162	NS	NS	NS	Emerald shiner	666	0.600	Channel shiner	602	0.096
3	Emerald shiner	418	0.080	NS	NS	NS	Gizzard shad	348	0.649	Gizzard shad	556	0.583
4	Sand shiner	200	0.038	NS	NS	NS	Channel shiner	263	0.130	Emerald shiner	462	0.179
5	Bullhead minnow	198	0.038	NS	NS	NS	Sicklefin chub	116	0.014	Bullhead minnow	177	0.140
6	Shoal chub	195	0.037	NS	NS	NS	Shoal chub	98	0.030	Shoal chub	141	0.024
7	Gizzard shad	170	0.033	NS	NS	NS	Bullhead minnow	35	0.037	Mosquitofish	104	0.015
8	Bluntnose minnow	35	0.007	NS	NS	NS	Sand shiner	30	0.010	Sicklefin chub	78	0.019
9	Mosquitofish	34	0.007	NS	NS	NS	Freshwater drum	19	0.031	Sand shiner	69	0.025
10	Freshwater drum	28	0.005	NS	NS	NS	Channel catfish	16	0.036	Blacktail chubs	49	0.005
11	Sicklefin chub	27	0.005	NS	NS	NS	Sturgeon chub	13	0.002	Bluntnose minnow	44	0.038
12	Orangespotted sunfish	18	0.003	NS	NS	NS	Bluntnose minnow	12	0.006	Freshwater drum	28	0.084
13	Goldeye	12	0.002	NS	NS	NS	Goldeye	10	0.022	Orangespotted sunfish	25	0.047
14	Bluegill	11	0.002	NS	NS	NS	White bass	7	0.005	Bluegill	20	0.016
15	Smallmouth buffalo	8	0.002	NS	NS	NS	Minnow Family	6	0.001	Goldeye	15	0.007
16	Sunfish - Lepomis	6	0.001	NS	NS	NS	Silver chub	4	0.001	Silver carp	15	0.007
17	Plains minnow	4	0.001	NS	NS	NS	Bluegill	3	0.005	Smallmouth buffalo	13	0.014
18	River carpsucker	4	0.001	NS	NS	NS	Silver carp	3	0.004	Channel catfish	11	0.023
19	River shiner	4	0.001	NS	NS	NS	Smallmouth buffalo	3	0.005	Pikeperch	10	0.010
20	Silver chub	4	0.001	NS	NS	NS	Blacktail chubs	2	0.000	River shiner	7	0.003
21	Rosyface shiner	3	0.001	NS	NS	NS	Buffalofish	2	0.001	Sturgeon chub	7	0.002
22	Sturgeon chub	3	0.001	NS	NS	NS	Golden redhorse	2	0.013	White bass	6	0.005
23	Bigeye shiner	2	0.000	NS	NS	NS	Largemouth bass	2	0.004	Carpsuckers	5	0.001
24	Brook silverside	2	0.000	NS	NS	NS	Pikeperch	2	0.002	Ghost shiner	5	0.001
25	Channel catfish	2	0.000	NS	NS	NS	River shiner	2	0.002	Buffalofish	4	0.000
26	Longnose gar	2	0.000	NS	NS	NS	Striped bass x white bass	2	0.027	Golden redhorse	3	0.001
27	Silver carp	2	0.000	NS	NS	NS	Banded killifish	1	0.027	Minnow Family	3	0.000
28	Blacktail chubs	1	0.000	NS	NS	NS	Blue catfish	1	0.027	River carpsucker	3	1.182
29	Blue catfish	1	0.000	NS	NS	NS	Flathead catfish	1	0.179	Common carp	2	0.006
30	Grass carp	1	0.000	NS	NS	NS	Plains killifish	1	0.000	Grass carp	2	0.000
31	Ghost shiner	1	0.000	NS	NS	NS	Rosyface shiner	1	0.001	Green sunfish	2	0.004
32	Largemouth bass	1	0.000	NS	NS	NS	Shiners - Notropis	1	0.000	Plains minnow	2	0.001
33	Sauger x Walley	1	0.000	NS	NS	NS	Spotted bass	1	0.001	Silver chub	2	0.000

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight
34	Spotted bass	1	0.000	NS	NS	NS	Suckermouth minnow	1	0.005	Spotted bass	2	0.001
35	Stonerollers	1	0.000	NS	NS	NS				Bigeye shiner	1	0.000
36	Temperate basses	1	0.000	NS	NS	NS				Brook silverside	1	0.001
37				NS	NS	NS				Creek chub	1	0.001
38				NS	NS	NS				Johnny darter	1	0.000
39				NS	NS	NS				Logperch	1	0.001
40				NS	NS	NS				Rosyface shiner	1	0.001
41				NS	NS	NS				Sunfish - Lepomis	1	0.000
Total	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight
	36	5221	0.71	0	0	0	34	2766	2.22	41	3636	2.89

Table B-2 Species composition (numbers caught and weight in kg) of fish sampled with electrofishing at the LEC in 2017-2018, by zone.

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight
1	Gizzard shad	192	6.116	Red shiner	330	0.162	Gizzard shad	346	24.950	Red shiner	659	0.143
2	Freshwater drum	173	0.150	Blue catfish	154	657.399	Emerald shiner	190	0.343	Gizzard shad	347	7.521
3	Blue catfish	81	0.070	River carpsucker	67	66.947	Red shiner	177	0.177	Emerald shiner	172	0.076
4	Longnose gar	62	0.054	Emerald shiner	59	0.094	Freshwater drum	99	35.768	Freshwater drum	129	25.817
5	River carpsucker	60	0.052	Gizzard shad	56	22.438	River carpsucker	92	98.209	Silver carp	97	130.312
6	Emerald shiner	59	0.051	Freshwater drum	46	39.517	Longnose gar	81	54.133	Shortnose gar	71	44.918
7	Red shiner	58	0.050	Longnose gar	35	23.762	Silver carp	79	144.381	River carpsucker	66	68.449
8	Silver carp	55	0.048	Shortnose gar	31	20.663	Shortnose gar	75	49.828	Blue catfish	65	129.927
9	Goldeye	52	0.045	Flathead catfish	22	57.945	Blue catfish	72	131.030	Flathead catfish	53	5.441
10	Shortnose gar	50	0.043	Common carp	20	71.394	Smallmouth buffalo	62	139.388	Longnose gar	50	32.564
11	Smallmouth buffalo	44	0.038	Channel catfish	19	21.036	Common carp	45	151.600	Goldeye	43	1.875
12	Channel catfish	43	0.037	Smallmouth buffalo	19	57.661	Goldeye	41	2.110	Common carp	41	121.116
13	Common carp	43	0.037	Silver carp	13	33.663	Flathead catfish	40	22.857	Channel shiner	38	0.029
14	Channel shiner	39	0.034	Striped bass x white bass	12	9.347	Channel catfish	25	11.916	Smallmouth buffalo	35	81.179
15	Flathead catfish	28	0.024	Goldeye	11	1.648	Channel shiner	20	0.017	Channel catfish	18	11.357
16	Grass carp	16	0.014	Channel shiner	10	0.007	Grass carp	14	90.115	Sand shiner	14	0.005
17	Bullhead minnow	15	0.013	Spotted bass	6	0.595	Blue sucker	13	20.138	Bullhead minnow	12	0.019
18	Black buffalo	9	0.008	Bullhead minnow	5	0.007	Bluegill	12	0.180	Grass carp	12	61.833
19	Bluegill	9	0.008	Shoal chub	5	0.003	Bullhead minnow	10	0.020	Blue sucker	11	13.126
20	Shovelnose sturgeon	9	0.008	Bighead carp	4	14.443	Spotted bass	10	0.848	Spotted bass	10	1.177
21	Orangespotted sunfish	8	0.007	Blue sucker	4	8.580	Black buffalo	8	27.658	Bluegill	9	0.258
22	Spotted bass	7	0.006	Sand shiner	4	0.003	Bigmouth buffalo	7	23.205	Bigmouth buffalo	7	11.161
23	Blue sucker	5	0.004	Quillback carpsucker	2	2.814	Green sunfish	6	0.052	Orangespotted sunfish	6	0.027
24	Green sunfish	4	0.003	Black buffalo	1	4.216	Mooneye	4	0.013	Shovelnose sturgeon	6	4.208
25	Walleye	4	0.003	Bluegill	1	0.068	Shovelnose sturgeon	4	2.734	Black buffalo	4	16.999
26	White bass	4	0.003	Chestnut lamprey	1	0.084	Shorthead redhorse	3	0.214	Bluntnose minnow	3	0.001
27	Logperch	3	0.003	Fathead minnow	1	0.002	Striped bass x white bass	3	1.521	Shorthead redhorse	2	0.736
28	Skipjack herring	3	0.003	Golden redhorse	1	0.128	White bass	3	0.728	Striped bass x white bass	2	0.103
29	White crappie	3	0.003	Grass carp	1	6.420	Freckled madtom	2	0.003	White bass	2	0.530
30	Bighead carp	2	0.002	Green sunfish	1	0.020	Orangespotted sunfish	2	0.013	Brook silverside	1	0.000
31	Bigmouth buffalo	2	0.002	Lake sturgeon	1	14.262	Quillback carpsucker	2	1.177	Chestnut lamprey	1	0.049
32	Bluntnose minnow	2	0.002	Orangespotted sunfish	1	0.009	White crappie	2	0.381	Goldfish	1	0.054

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight
33	Brook silverside	1	0.001	Sauger	1	0.074	Black crappie	1	0.000	Logperch	1	0.003
34	Central stoneroller	1	0.001	Shorthead redhorse	1	0.392	Bluntnose minnow	1	0.001	Longear sunfish	1	0.065
35	Freckled madtom	1	0.001	Shovelnose sturgeon	1	0.430	Golden redhorse	1	0.212	Mooneye	1	0.018
36	Lake sturgeon	1	0.001	Suckermouth minnow	1	0.008	Goldfish	1	0.013	Rosyface shiner	1	0.002
37	Largescale stoneroller	1	0.001	White bass	1	0.000	Sand shiner	1	0.001	Skipjack herring	1	0.170
38	Mooneye	1	0.001				Sauger	1	0.733	Walleye	1	0.372
39	River shiner	1	0.001				Sauger x Walleye	1	0.135	White crappie	1	0.104
40	Sauger	1	0.001				Shoal chub	1	0.001			
41	Shoal chub	1	0.001				Silver lamprey	1	0.060			
42	Shorthead redhorse	1	0.001				Silver redhorse	1	0.018			
43	Silver chub	1	0.001				Skipjack herring	1	0.661			
44	Suckermouth minnow	1	0.001				Spotted sucker	1	0.190			
Total	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight
	44	1156	6.95	37	948	1136.24	44	1561	1037.73	39	1994	771.74

Table B-3 Species composition (numbers caught and weight in kg) of fish sampled with hoop net at the LEC in 2017-2018, by zone. NS indicated no sampling in the zone.

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight
1	Shovelnose sturgeon	41	25.597	NS	NS	NS	Blue sucker	29	74.455	Shovelnose sturgeon	35	38.291
2	Blue sucker	30	0.199	NS	NS	NS	Smallmouth buffalo	19	47.619	Blue sucker	23	51.735
3	Blue catfish	16	0.106	NS	NS	NS	Freshwater drum	14	11.086	Blue catfish	22	111.945
4	Freshwater drum	16	0.106	NS	NS	NS	Shovelnose sturgeon	14	9.611	Freshwater drum	14	14.412
5	Smallmouth buffalo	11	0.073	NS	NS	NS	River carpsucker	8	8.824	Goldeye	12	3.396
6	River carpsucker	10	0.066	NS	NS	NS	Flathead catfish	7	22.736	Smallmouth buffalo	12	29.384
7	Common carp	8	0.053	NS	NS	NS	Blue catfish	6	6.154	Flathead catfish	10	28.133
8	Flathead catfish	4	0.026	NS	NS	NS	Common carp	5	21.054	River carpsucker	8	10.468
9	Silver carp	3	0.020	NS	NS	NS	Goldeye	5	1.642	Common carp	5	21.806
10	Channel catfish	2	0.013	NS	NS	NS	Silver carp	5	13.002	Silver carp	4	7.180
11	Longnose gar	2	0.013	NS	NS	NS	Longnose gar	3	8.120	Channel catfish	3	6.250
12	Shorthead redhorse	2	0.013	NS	NS	NS	Shorthead redhorse	3	1.264	Longnose gar	3	10.890
13	Bighead carp	1	0.007	NS	NS	NS	Bigmouth buffalo	2	5.178	Bighead carp	2	18.220
14	Goldeye	1	0.007	NS	NS	NS	Channel catfish	2	1.079	Striped bass x white bass	2	0.880
15	Lake sturgeon	1	0.007	NS	NS	NS	Grass carp	2	13.575	Gizzard shad	1	0.850
16	Paddlefish	1	0.007	NS	NS	NS	Black buffalo	1	4.430	Grass carp	1	6.200
17	Sauger	1	0.007	NS	NS	NS	Sauger x Walleye	1	0.600	Mooneye	1	0.220
18	White bass	1	0.007	NS	NS	NS	Striped bass x white bass	1	0.390	Sauger x Walleye	1	1.930
Total	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight
	18	151	26.33	0	0	0	18	127	250.82	18	159	362.19

Table B-4 Species composition (numbers caught and weight in kg) of fish sampled with Missouri mini-trawl at the LEC in 2017-2018, by zone. NS indicated no sampling in the zone.

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight	Taxon	Count	Weight
1	Sicklefin chub	541	0.143	NS	NS	NS	Sicklefin chub	511	0.156	Shoal chub	490	0.099
2	Channel shiner	400	0.152	NS	NS	NS	Shoal chub	508	0.120	Channel shiner	412	0.126
3	Shoal chub	363	0.138	NS	NS	NS	Channel shiner	460	0.138	Sicklefin chub	394	0.112
4	Freshwater drum	270	0.103	NS	NS	NS	Freshwater drum	239	2.571	Channel catfish	224	0.573
5	Blue catfish	252	0.096	NS	NS	NS	Blue catfish	203	1.374	Blue catfish	183	2.710
6	Channel catfish	232	0.088	NS	NS	NS	Channel catfish	199	0.743	Freshwater drum	104	3.223
7	Gizzard shad	195	0.074	NS	NS	NS	Silver carp	80	4.539	Bullhead minnow	97	0.045
8	Silver carp	95	0.036	NS	NS	NS	Gizzard shad	63	0.088	Gizzard shad	76	0.092
9	Goldeye	50	0.019	NS	NS	NS	Bullhead minnow	59	0.024	Goldeye	71	0.055
10	Bullhead minnow	42	0.016	NS	NS	NS	Emerald shiner	58	0.091	Blacktail chubs	68	0.005
11	Red shiner	26	0.010	NS	NS	NS	Blacktail chubs	47	0.005	Silver carp	37	1.376
12	Emerald shiner	18	0.007	NS	NS	NS	Orangespotted sunfish	44	0.007	Sturgeon chub	25	0.012
13	Blacktail chubs	13	0.005	NS	NS	NS	Goldeye	34	0.072	White bass	14	0.004
14	Silver chub	13	0.005	NS	NS	NS	Sturgeon chub	23	0.008	Red shiner	10	0.003
15	Shovelnose sturgeon	12	0.005	NS	NS	NS	Red shiner	22	0.015	Shovelnose sturgeon	7	2.080
16	White bass	11	0.004	NS	NS	NS	Shovelnose sturgeon	19	9.337	Silver/bighead carp	6	0.003
17	Sucker - Ictiobinae	10	0.004	NS	NS	NS	Shortnose gar	11	6.491	Paddlefish	5	0.001
18	Minnow Family	8	0.003	NS	NS	NS	Paddlefish	10	0.004	Silver chub	5	0.001
19	Sunfish - Lepomis	8	0.003	NS	NS	NS	White bass	10	0.002	Sunfish - Lepomis	5	0.001
20	Pikeperch	7	0.003	NS	NS	NS	Sand shiner	6	0.002	Orangespotted sunfish	4	0.001
21	Sturgeon chub	7	0.003	NS	NS	NS	Common carp	5	0.002	Blue sucker	3	1.290
22	Sunfish - Pomoxis	6	0.002	NS	NS	NS	Silver chub	5	0.002	Bluegill	3	0.002
23	Paddlefish	5	0.002	NS	NS	NS	Bluegill	3	0.001	Common carp	3	0.008
24	Sand shiner	5	0.002	NS	NS	NS	Mooneyes	3	0.000	Longnose gar	3	2.092
25	Buffalofish	4	0.002	NS	NS	NS	Sunfish - Lepomis	3	0.000	Bluntnose minnow	2	0.001
26	Minnow Family group 2	4	0.002	NS	NS	NS	Flathead catfish	2	0.484	Emerald shiner	2	0.003
27	Silver/bighead carp	4	0.002	NS	NS	NS	Grass carp	2	0.005	Flathead catfish	2	0.004
28	Common carp	3	0.001	NS	NS	NS	Gravel chub	2	0.010	Golden redhorse	2	0.000
29	Orangespotted sunfish	2	0.001	NS	NS	NS	Logperch	2	0.000	Minnow Family	2	0.000
30	Shortnose gar	2	0.001	NS	NS	NS	Longnose gar	2	1.700	Mooneye	2	0.000
31	Spotted bass	2	0.001	NS	NS	NS	Minnow Family group 2	2	0.000	Mooneyes	2	0.000
32	Bluegill	1	0.000	NS	NS	NS	Sauger x Walleye	2	0.001	Buffalofish	1	0.000
33	Bluntnose minnow	1	0.000	NS	NS	NS	Sucker - Ictiobinae	2	0.000	Ghost shiner	1	0.000
34	Flathead catfish	1	0.000	NS	NS	NS	Sunfish – Pomoxis	2	0.000	Grass carp	1	0.003
35	Golden redhorse	1	0.000	NS	NS	NS	Bluntnose minnow	1	0.000	Mosquitofish	1	0.000

Rank	Upstream			Discharge			Thermally Exposed			Downstream		
	Taxon	**Count**	**Weight**	**Taxon**	**Count**	**Weight**	**Taxon**	**Count**	**Weight**	**Taxon**	**Count**	**Weight**
36	Grass carp	1	0.000	NS	NS	NS	Catfish (Ictalurus)	1	0.000	Sand shiner	1	0.000
37	Mooneyes	1	0.000	NS	NS	NS	Madtoms	1	0.000	Shiners - Notropis	1	0.000
38	Mosquitofish	1	0.000	NS	NS	NS	Shiners – Notropis	1	0.000	Smallmouth buffalo	1	1.280
39	River shiner	1	0.000	NS	NS	NS	Silverband shiner	1	0.001	Sucker - Ictiobinae	1	0.000
40	Shiners - Notropis	1	0.000	NS	NS	NS	Sturgeon – Scaphirhynchus	1	0.000	Sucker - Redhorses	1	0.000
41	Sturgeon - Scaphirhynchus	1	0.000	NS	NS	NS	Unidentifiedr	1	0.000	Temperate basses	1	0.000
42	Sucker - Catostominae	1	0.000	NS	NS	NS				Unidentified	1	0.000
43	Sucker - Catostomus	1	0.000	NS	NS	NS						
Total	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight	Taxa	Count	Weight
	44	2622	0.94	0	0	0	41	2650	27.99	42	2274	15.20

Table B-5 Sampling statistics for fish monitoring program at LEC in 2017-2018 by gear, zone, and season. NS indicated no sampling in the zone.

Gear	Statistic	Upstream				Discharge				Thermally Exposed				Downstream			
		Win	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win	Spr	Sum	Fal
Bag Seine	Samples	10	6	8	8	NS	NS	NS	NS	10	6	8	8	10	6	8	8
	Count	745	248	445	3782	NS	NS	NS	NS	847	306	900	712	273	998	1463	902
	Weight (kg)	0.32	0.38	0.92	1.63	NS	NS	NS	NS	0.28	0.52	0.68	0.74	0.15	1.68	0.63	0.44
	Mn ct density	65.62	25.57	70.61	250.49	NS	NS	NS	NS	58.86	26.58	74.97	63.84	18.45	136.66	155.06	121.46
	se ct density	24.45	12.97	25.49	100.04	NS	NS	NS	NS	35.56	3.43	35.24	22.78	5.83	79.08	51.87	68.44
	Mn wt density	0.03	0.03	0.15	0.14	NS	NS	NS	NS	0.02	0.04	0.05	0.06	0.01	0.22	0.06	0.06
	se wt density	0.01	0.01	0.1	0.08	NS	NS	NS	NS	0.01	0.01	0.02	0.02	0	0.17	0.02	0.03
Electro-fishing	Samples	18	18	18	17	6	6	6	6	18	18	18	18	18	18	18	18
	Count	319	327	368	142	558	177	67	146	654	332	273	302	1140	287	285	282
	Weight (kg)	305.01	258.57	117.29	136.73	449.8	235.97	32.05	418.43	324.24	278.32	174.62	260.56	257.57	214.86	120.72	178.59
	Mn ct density	17	15.94	17.4	8.08	84.91	26.52	10.39	22.46	32.7	16.46	14.16	15.72	58.33	14.89	15.15	14.45
	se ct density	3.9	1.77	4.28	1.53	35.64	3.92	4.8	5.56	7.08	2.98	3.61	3.28	30.2	2.8	4.09	3.61
	Mn wt density	16.39	12.56	5.58	7.98	66.22	35.95	4.8	64.55	16.38	13.65	8.5	13.58	12.52	11.07	6.2	9.31
	se wt density	3.52	1.23	1.18	1.43	16.8	12.17	2.55	19	3.5	2.83	1.44	3.15	2.49	1.68	0.8	2.73
Hoop Net	Samples	18	18	18	18	NS	NS	NS	NS	18	18	18	18	18	18	18	18
	Count	28	51	42	30	NS	NS	NS	NS	36	36	21	34	32	57	31	39
	Weight (kg)	38.29	82.36	77.72	43.42	NS	NS	NS	NS	70.3	81.4	38.76	60.36	74.43	147.99	80.82	58.96
	Mn ct density	1.46	2.86	2.38	1.68	NS	NS	NS	NS	2.02	2.03	1.19	1.9	1.8	3.2	1.76	2.31
	se ct density	0.77	0.6	0.62	0.58	NS	NS	NS	NS	1.02	0.48	0.35	0.65	0.7	1.42	0.45	0.49
	Mn wt density	1.99	4.61	4.38	2.42	NS	NS	NS	NS	3.94	4.58	2.2	3.38	4.22	8.29	4.57	3.45
	se wt density	1.17	1.24	1.3	1.06	NS	NS	NS	NS	2.73	1.37	0.79	1.66	2.27	3.77	1.28	0.98
Missouri mini-trawl	Samples	24	24	24	24	NS	NS	NS	NS	24	24	24	24	24	24	24	24
	Count	247	613	1011	753	NS	NS	NS	NS	325	575	665	1087	371	475	784	645
	Weight (kg)	10.01	0.93	6.9	3.78	NS	NS	NS	NS	10.38	7.07	1.44	9.11	9.21	2.75	1.4	1.84
	Mn ct density	11.11	25	43.6	32.09	NS	NS	NS	NS	12.32	20.61	26.84	42.26	18.09	22.73	36.29	32.15
	se ct density	2.86	7.22	10.07	13.84	NS	NS	NS	NS	3.11	6.26	7.79	19.09	4.88	5.83	10.01	19.88
	Mn wt density	0.44	0.04	0.29	0.15	NS	NS	NS	NS	0.44	0.28	0.05	0.36	0.5	0.13	0.07	0.07
	se wt density	0.16	0.02	0.2	0.05	NS	NS	NS	NS	0.18	0.12	0.03	0.18	0.16	0.07	0.02	0.05

Table B-6 Sample size, estimated diversity and standard deviation at q = 0, 1, 2, and 3 for fish sampled with bag seine at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream			Discharge			Thermally Exposed			Downstream		
		Count		Weight	Count		Weight	Count		Weight	Count		Weight
		Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate
Winter	N	745	-	-	NS	-	-	847	-	-	273	-	-
	^{0}D	18	1.02	18	NS	NS	NS	16	2.33	15	15	1.05	15
	^{1}D	7.3	0.25	8.4	NS	NS	NS	3.2	0.15	5.3	4.8	0.37	5.1
	^{2}D	5.8	0.18	6.3	NS	NS	NS	2	0.08	4	2.7	0.22	3.4
	^{3}D	5.3	0.16	5.5	NS	NS	NS	1.8	0.06	3.5	2.3	0.16	2.9
Spring	N	248	-	-	NS	-	-	306	-	-	998	-	-
	^{0}D	20	1.73	20	NS	NS	NS	23	1.5	23	28	1.9	28
	^{1}D	7.6	0.62	7.9	NS	NS	NS	10.9	0.62	8	5.8	0.26	3.4
	^{2}D	5.2	0.41	5.7	NS	NS	NS	8	0.49	5.4	3.7	0.12	2
	^{3}D	4.5	0.34	4.8	NS	NS	NS	7	0.46	4.5	3.3	0.09	1.7
Summer	N	445	-	-	NS	-	-	900	-	-	1463	-	-
	^{0}D	15	1.41	15	NS	NS	NS	15	1.93	15	26	1.74	26
	^{1}D	7.2	0.32	3.6	NS	NS	NS	3.9	0.11	4	5.8	0.18	4.3
	^{2}D	5.8	0.25	2.4	NS	NS	NS	3.4	0.05	3	4.2	0.1	2.4
	^{3}D	5.2	0.25	2.1	NS	NS	NS	3.3	0.04	2.7	3.8	0.09	2
Fall	N	3782	-	-	NS	-	-	712	-	-	902	-	-
	^{0}D	22	1.81	22	NS	NS	NS	18	1.61	18	20	1.33	20
	^{1}D	3	0.06	5.6	NS	NS	NS	6.1	0.23	5.8	7.8	0.27	11.1
	^{2}D	1.9	0.03	4	NS	NS	NS	4.5	0.17	4.2	5.6	0.23	8.8
	^{3}D	1.7	0.02	3.4	NS	NS	NS	4	0.16	3.8	4.7	0.24	7.9

Table B-7 Sample size, estimated diversity and standard deviation at q = 0, 1, 2, and 3 for fish sampled with electrofishing at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream			Discharge			Thermally Exposed			Downstream		
		Count		Weight	Count		Weight	Count		Weight	Count		Weight
		Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate
Winter	N	319	-	-	558	-	-	654	-	-	1140	-	-
	^{0}D	28	2.49	28	29	3.18	29	30	3.44	30	31	2.84	31
	^{1}D	12.6	0.87	8.8	6.4	0.48	5.3	10.5	0.56	9	6.2	0.3	8.6
	^{2}D	8.7	0.69	7.3	3.1	0.2	3	7.1	0.33	7.1	3.4	0.16	6.7
	^{3}D	7.1	0.68	6.6	2.5	0.14	2.4	6.1	0.28	6.5	2.7	0.12	5.9
Spring	N	327	-	-	177	-	-	332	-	-	287	-	-
	^{0}D	33	2.36	33	22	1.62	22	27	1.23	27	30	2.87	30
	^{1}D	17.2	1.08	10.6	12.8	0.97	8.2	16.3	0.85	12.1	17.1	1.19	10.5
	^{2}D	12.9	0.83	8.3	10	0.77	5	11.8	0.91	9.8	12.5	1.1	8
	^{3}D	11.2	0.79	7.4	8.9	0.69	3.8	9.5	0.93	8.5	10.3	1.17	7
Summer	N	368	-	-	67	-	-	273	-	-	285	-	-
	^{0}D	29	1.82	29	14	0.98	14	30	3.18	30	23	1.75	23
	^{1}D	11.6	0.78	11.7	11.3	1	6.5	13.7	1.17	10.4	11.7	0.82	11
	^{2}D	6.2	0.57	9.9	9.4	1.12	5.6	8	0.9	8.4	7	0.73	9.3
	^{3}D	4.6	0.44	9	8.3	1.16	5.2	5.8	0.72	7.5	5.2	0.6	8.4
Fall	N	142	-	-	146	-	-	302	-	-	282	-	-
	^{0}D	23	2.17	23	18	1.6	18	24	2.02	24	22	1.31	22
	^{1}D	11.7	1.45	10.4	7.3	0.85	3.1	11.6	0.82	9.9	9	0.69	10.6
	^{2}D	6.6	1.15	8.3	4	0.55	1.8	7.7	0.68	7.9	5.2	0.49	9.1
	^{3}D	4.8	0.87	7.2	3.2	0.43	1.6	6.1	0.62	7.1	4.1	0.39	8.3

Table B-8 Sample size, estimated diversity and standard deviation at q = 0, 1, 2, and 3 for fish sampled with hoop net at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream			Discharge			Thermally Exposed			Downstream		
		Count		Weight	Count		Weight	Count		Weight	Count		Weight
		Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate
Winter	N	28	-	-	NS	-	-	36	-	-	32	-	-
	^0D	8	1.87	8	NS	NS	NS	7	1.07	7	10	1.77	10
	^1D	3.7	1.24	2.3	NS	NS	NS	3.7	0.69	1.8	6.5	1.52	3.6
	^2D	2.3	0.69	1.5	NS	NS	NS	2.5	0.49	1.3	4.8	1.3	2.7
	^3D	1.9	0.49	1.4	NS	NS	NS	2.1	0.38	1.2	4	1.13	2.5
Spring	N	51	-	-	NS	-	-	36	-	-	57	-	-
	^0D	8	0.72	8	NS	NS	NS	11	1.47	10	11	1.32	11
	^1D	6.6	0.58	6.5	NS	NS	NS	8.9	1.35	6.8	5.9	0.96	6
	^2D	5.8	0.62	5.3	NS	NS	NS	7.8	1.36	5.7	3.7	0.72	4.1
	^3D	5.3	0.64	4.5	NS	NS	NS	7.1	1.37	5.2	3	0.58	3.4
Summer	N	42	-	-	NS	-	-	21	-	-	31	-	-
	^0D	11	1.51	11	NS	NS	NS	9	1.48	9	11	1.53	11
	^1D	7.5	1.18	7.7	NS	NS	NS	7.7	1.41	7.4	9.1	1.37	9.1
	^2D	6	1.02	5.9	NS	NS	NS	7	1.38	6.5	8.1	1.34	8.3
	^3D	5.3	0.92	5	NS	NS	NS	6.6	1.35	6	7.5	1.31	7.9
Fall	N	30	-	-	NS	-	-	34	-	-	39	-	-
	^0D	8	1.43	8	NS	NS	NS	13	1.63	13	11	1.37	11
	^1D	4.9	1.03	5.5	NS	NS	NS	9.4	1.54	7.7	8.8	1.13	8.8
	^2D	3.5	0.82	4.7	NS	NS	NS	7.4	1.44	6	7.6	1.09	7.8
	^3D	3	0.7	4.4	NS	NS	NS	6.5	1.32	5.2	6.9	1.08	7.2

Table B-9 Sample size, estimated diversity and standard deviation at q = 0, 1, 2, and 3 for fish sampled with Missouri mini-trawl at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream			Discharge			Thermally Exposed			Downstream		
		Count		Weight	Count		Weight	Count		Weight	Count		Weight
		Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate	Estimate	StdDev	Estimate
Winter	N	247	-	-	NS	-	-	325	-	-	371	-	-
	^0D	16	1.45	16	NS	NS	NS	19	1.22	19	22	2.35	21
	^1D	8.2	0.53	4.3	NS	NS	NS	7.7	0.52	4.2	7.8	0.52	6.3
	^2D	6.4	0.37	3.2	NS	NS	NS	5	0.37	3.5	5.3	0.32	5.4
	^3D	5.8	0.33	2.8	NS	NS	NS	4.2	0.31	3.2	4.6	0.27	5
Spring	N	613	-	-	NS	-	-	575	-	-	475	-	-
	^0D	28	3.41	28	NS	NS	NS	31	1.76	31	28	2.46	27
	^1D	10.6	0.54	5.9	NS	NS	NS	10.4	0.59	2.8	11	0.57	4.9
	^2D	8	0.37	4.2	NS	NS	NS	6.5	0.41	1.9	8.2	0.39	3.4
	^3D	7	0.4	3.7	NS	NS	NS	5.2	0.37	1.7	7.2	0.41	2.9
Summer	N	1011	-	-	NS	-	-	665	-	-	784	-	-
	^0D	28	2.12	28	NS	NS	NS	21	1.48	21	22	1.94	21
	^1D	10.7	0.35	2.7	NS	NS	NS	11.2	0.39	3.9	9.7	0.35	6.2
	^2D	8.3	0.27	1.8	NS	NS	NS	9.1	0.42	2.5	7.3	0.32	4.6
	^3D	7.4	0.3	1.6	NS	NS	NS	7.9	0.46	2.2	6.3	0.32	4.1
Fall	N	753	-	-	NS	-	-	1087	-	-	645	-	-
	^0D	15	1.03	15	NS	NS	NS	22	1.69	22	18	1.42	16
	^1D	5.4	0.22	2.8	NS	NS	NS	6.2	0.22	5.1	5.7	0.26	2.6
	^2D	3.7	0.16	1.8	NS	NS	NS	4.6	0.13	3.4	4.1	0.15	1.8
	^3D	3.2	0.14	1.6	NS	NS	NS	4.2	0.1	2.9	3.8	0.13	1.6

Table B-10 Count and weight (kg) by fish type for fish sampled with bag seine at the LEC in 2017-2018, by season, and zone. R = Rough, F = Forage, P = Panfish, G = Gamefish, and S = Special Interest. NS indicated no sampling in the zone.

Season	Statistic	Upstream					Discharge					Thermally Exposed					Downstream				
		R	F	P	G	S	R	F	P	G	S	R	F	P	G	S	R	F	P	G	S
Winter	Count	9	732	4	0		NS	NS	NS	NS	NS	5	842	0	1		10	257	6	0	
	Fraction	0.012	0.983	0.005	0		NS	NS	NS	NS	NS	0.006	0.993	0	0.001		0.037	0.941	0.022	0	
	Weight	0.030	0.286	0.005	0		NS	NS	NS	NS	NS	0.024	0.238	0	0.013		0.042	0.102	0.006	0	
	Fraction	0.093	0.891	0.017	0		NS	NS	NS	NS	NS	0.088	0.863	0	0.049		0.280	0.680	0.041	0	
	Total Ct	745					NS					848					273				
	Total Wt	0.322					NS					0.276					0.15				
Spring	Count	26	212	5	6		NS	NS	NS	NS	NS	54	223	8	21		54	907	20	19	
	Fraction	0.104	0.851	0.020	0.024		NS	NS	NS	NS	NS	0.176	0.729	0.026	0.069		0.052	0.909	0.020	0.019	
	Weight	0.129	0.172	0.031	0.050		NS	NS	NS	NS	NS	0.058	0.240	0.008	0.217		1.263	0.376	0.021	0.020	
	Fraction	0.338	0.450	0.082	0.130		NS	NS	NS	NS	NS	0.110	0.460	0.015	0.415		0.752	0.224	0.013	0.012	
	Total Ct	249					NS					306					998				
	Total Wt	0.383					NS					0.521					1.681				
Summer	Count	89	338	18	0		NS	NS	NS	NS	NS	2690	628	0	3		531	899	17	16	
	Fraction	0.200	0.760	0.040	0		NS	NS	NS	NS	NS	0.299	0.698	0	0.003		0.363	0.614	0.012	0.011	
	Weight	0.790	0.116	0.014	0		NS	NS	NS	NS	NS	0.341	0.309	0	0.028		0.413	0.178	0.028	0.007	
	Fraction	0.858	0.126	0.015	0		NS	NS	NS	NS	NS	0.503	0.456	0	0.041		0.660	0.285	0.045	0.010	
	Total Ct	445					NS					900					1463				
	Total Wt	0.92					NS					0.677					0.626				
Fall	Count	83	3682	9	8		NS	NS	NS	NS	NS	44	661	2	5		21	865	11	5	
	Fraction	0.022	0.974	0.002	0.002		NS	NS	NS	NS	NS	0.062	0.928	0.003	0.007		0.023	0.959	0.012	0.006	
	Weight	1.019	0.595	0.008	0.009		NS	NS	NS	NS	NS	0.275	0.441	0.002	0.024		0.145	0.252	0.017	0.022	
	Fraction	0.625	0.365	0.005	0.005		NS	NS	NS	NS	NS	0.370	0.594	0.003	0.033		0.333	0.580	0.038	0.049	
	Total Ct	3782					NS					712					902				
	Total Wt	1.630					NS					0.742					0.435				

Table B-11 Count and weight (kg) by fish type for fish sampled with electrofishing at the LEC in 2017-2018, by season, and zone. R = Rough, F = Forage, P = Panfish, G = Gamefish, and S = Special Interest. NS indicated no sampling in the zone.

Season	Statistic	Upstream					Discharge					Thermally Exposed					Downstream				
		R	F	P	G	S	R	F	P	G	S	R	F	P	G	S	R	F	P	G	S
Winter	Count	192	69	5	51	2	126	337	1	93	1	317	270	12	55	0	296	788	6	49	1
	Fraction	0.602	0.216	0.016	0.160	0.006	0.226	0.604	0.002	0.167	0.002	0.485	0.413	0.018	0.084	0.000	0.260	0.691	0.005	0.043	0.001
	Weight	216.651	0.410	0.572	86.017	1.360	127.958	1.686	0.020	319.704	0.430	238.305	2.386	0.603	82.945	0.000	164.609	0.327	0.212	91.395	1.030
	Fraction	0.710	0.001	0.002	0.282	0.004	0.284	0.004	0.000	0.711	0.001	0.735	0.007	0.002	0.256	0.000	0.639	0.001	0.001	0.355	0.004
	Total Ct	319					558					654					1140				
	Total Wt	305.01					449.80					324.24					257.57				
Spring	Count	161	71	16	77	2	89	44	3	40	1	173	92	9	56	2	141	83	10	52	1
	Fraction	0.492	0.217	0.049	0.235	0.006	0.503	0.249	0.017	0.226	0.006	0.521	0.277	0.027	0.169	0.006	0.491	0.289	0.035	0.181	0.003
	Weight	167.700	0.305	2.823	80.171	7.567	92.601	0.066	0.077	128.960	14.262	204.332	0.137	0.691	72.227	0.934	163.358	0.627	0.759	49.147	0.970
	Fraction	0.649	0.001	0.011	0.310	0.029	0.392	0.000	0.000	0.547	0.060	0.734	0.000	0.002	0.260	0.003	0.760	0.003	0.004	0.229	0.005
	Total Ct	327					177					332					327				
	Total Wt	258.565					235.966					278.321					258.57				
Summer	Count	218	84	5	56	5	20	26	0	21	0	162	51	4	56	0	170	52	1	58	4
	Fraction	0.592	0.228	0.014	0.152	0.014	0.299	0.388	0.000	0.313	0.000	0.593	0.187	0.015	0.205	0.000	0.596	0.182	0.004	0.204	0.014
	Weight	88.455	0.685	0.119	24.576	3.459	20.834	0.208	0.000	11.009	0.000	89.624	0.149	0.040	84.803	0.000	76.779	0.614	0.005	41.119	2.208
	Fraction	0.754	0.006	0.001	0.210	0.029	0.650	0.006	0.000	0.343	0.000	0.513	0.001	0.000	0.486	0.000	0.636	0.005	0.000	0.341	0.018
	Total Ct	368					67					273					368				
	Total Wt	117.295					32.051					174.616					117.29				
Fall	Count	97	16	2	26	1	47	20	0	79	0	209	36	1	54	2	224	24	2	32	0
	Fraction	0.683	0.113	0.014	0.183	0.007	0.322	0.137	0.000	0.541	0.000	0.692	0.119	0.003	0.179	0.007	0.794	0.085	0.007	0.113	0.000
	Weight	83.529	0.600	0.078	52.028	0.490	73.984	0.058	0.000	344.384	0.000	166.344	0.735	0.020	91.658	1.800	118.700	0.823	0.008	59.056	0.000
	Fraction	0.611	0.004	0.001	0.381	0.004	0.177	0.000	0.000	0.823	0.000	0.638	0.003	0.000	0.352	0.007	0.665	0.005	0.000	0.331	0.000
	Total Ct	142					146					302					282				
	Total Wt	136.73					418.43					260.56					178.59				

Table B-12 Count and weight (kg) by fish type for fish sampled with hoop net at the LEC in 2017-2018, by season, and zone. R = Rough, F = Forage, P = Panfish, G = Gamefish, and S = Special Interest. NS indicated no sampling in the zone.

Season	Statistic	Upstream					Discharge					Thermally Exposed					Downstream				
		R	F	P	G	S	R	F	P	G	S	R	F	P	G	S	R	F	P	G	S
Winter	Count	22	0	0	3	3	NS	NS	NS	NS	NS	25	4	0	4	3	16	7	0	8	1
	Fraction	0.786	0.000	0.000	0.107	0.107	NS	NS	NS	NS	NS	0.694	0.111	0.000	0.111	0.083	0.500	0.219	0.000	0.250	0.031
	Weight	34.178	0.000	0.000	1.930	2.177	NS	NS	NS	NS	NS	62.520	1.332	0.000	4.238	2.206	32.540	1.872	0.000	39.410	0.610
	Fraction	0.893	0.000	0.000	0.050	0.057	NS	NS	NS	NS	NS	0.889	0.019	0.000	0.060	0.031	0.437	0.025	0.000	0.529	0.008
	Total Ct	28					NS					36					32				
	Total Wt	38.29					NS					70.30					74.432				
Spring	Count	24	0	0	14	13	NS	NS	NS	NS	NS	17	0	0	14	5	13	0	0	17	27
	Fraction	0.471	0.000	0.000	0.275	0.255	NS	NS	NS	NS	NS	0.472	0.000	0.000	0.389	0.139	0.228	0.000	0.000	0.298	0.474
	Weight	43.151	0.000	0.000	32.550	6.662	NS	NS	NS	NS	NS	39.160	0.000	0.000	38.731	3.513	29.362	0.000	0.000	86.136	32.487
	Fraction	0.524	0.000	0.000	0.395	0.081	NS	NS	NS	NS	NS	0.481	0.000	0.000	0.476	0.043	0.198	0.000	0.000	0.582	0.220
	Total Ct	51					NS					36					57				
	Total Wt	82.36					NS					81.40					147.99				
Summer	Count	17	0	0	13	12	NS	NS	NS	NS	NS	11	0	0	6	4	15	0	0	15	1
	Fraction	0.405	0.000	0.000	0.310	0.286	NS	NS	NS	NS	NS	0.524	0.000	0.000	0.286	0.190	0.484	0.000	0.000	0.484	0.032
	Weight	35.962	0.000	0.000	30.220	11.542	NS	NS	NS	NS	NS	24.246	0.000	0.000	11.748	2.761	51.428	0.000	0.000	28.150	1.240
	Fraction	0.463	0.000	0.000	0.389	0.148	NS	NS	NS	NS	NS	0.626	0.000	0.000	0.303	0.071	0.636	0.000	0.000	0.348	0.015
	Total Ct	42					NS					21					31				
	Total Wt	77.72					NS					38.76					80.82				
Fall	Count	9	1	1	4	15	NS	NS	NS	NS	NS	17	1	0	14	2	17	6	0	10	6
	Fraction	0.300	0.033	0.033	0.133	0.500	NS	NS	NS	NS	NS	0.500	0.029	0.000	0.412	0.059	0.436	0.154	0.000	0.256	0.154
	Weight	15.104	0.471	0.501	5.381	21.964	NS	NS	NS	NS	NS	29.884	0.310	0.000	29.039	1.131	28.431	1.744	0.000	24.826	3.954
	Fraction	0.348	0.011	0.012	0.124	0.506	NS	NS	NS	NS	NS	0.495	0.005	0.000	0.481	0.019	0.482	0.030	0.000	0.421	0.067
	Total Ct	30					NS					34					39				
	Total Wt	43.42					NS					60.36					58.96				

Table B-13 Count and weight (kg) by fish type for fish sampled with Missouri mini-trawl at the LEC in 2017-2018, by season, and zone. R = Rough, F = Forage, P = Panfish, G = Gamefish, and S = Special Interest. NS indicated no sampling in the zone.

Season	Statistic	Upstream					Discharge					Thermally Exposed					Downstream				
		R	F	P	G	S	R	F	P	G	S	R	F	P	G	S	R	F	P	G	S
Winter	Count	26	120	2	95	4	NS	NS	NS	NS	NS	31	243	1	50	0	19	273	2	74	3
	Fraction	0.105	0.486	0.008	0.385	0.016	NS	NS	NS	NS	NS	0.095	0.748	0.003	0.154	0.000	0.051	0.736	0.005	0.199	0.008
	Weight	7.488	0.057	0.001	0.604	1.863	NS	NS	NS	NS	NS	9.846	0.084	0.000	0.446	0.000	5.121	0.083	0.001	3.368	0.640
	Fraction	0.748	0.006	0.000	0.060	0.186	NS	NS	NS	NS	NS	0.949	0.008	0.000	0.043	0.000	0.556	0.009	0.000	0.366	0.069
	Total Ct	247					NS					325					371				
	Total Wt	10.01					NS					10.38					9.21				
Spring	Count	247	251	17	89	7	NS	NS	NS	NS	NS	213	256	14	71	19	57	317	16	78	7
	Fraction	0.404	0.411	0.028	0.146	0.011	NS	NS	NS	NS	NS	0.372	0.447	0.024	0.124	0.033	0.120	0.667	0.034	0.164	0.015
	Weight	0.136	0.132	0.002	0.609	0.053	NS	NS	NS	NS	NS	1.091	0.190	0.003	0.827	4.960	1.990	0.158	0.004	0.495	0.106
	Fraction	0.146	0.142	0.002	0.653	0.057	NS	NS	NS	NS	NS	0.154	0.027	0.000	0.117	0.701	0.723	0.058	0.001	0.180	0.038
	Total Ct	611					NS					573					475				
	Total Wt	0.93					NS					7.07					2.75				
Summer	Count	263	473	9	264	2	NS	NS	NS	NS	NS	119	298	45	200	3	115	425	8	236	0
	Fraction	0.260	0.468	0.009	0.261	0.002	NS	NS	NS	NS	NS	0.179	0.448	0.068	0.301	0.005	0.147	0.542	0.010	0.301	0.000
	Weight	5.154	0.092	0.002	0.960	0.691	NS	NS	NS	NS	NS	0.957	0.076	0.006	0.399	0.000	0.923	0.133	0.001	0.348	0.000
	Fraction	0.747	0.013	0.000	0.139	0.100	NS	NS	NS	NS	NS	0.665	0.053	0.004	0.277	0.000	0.657	0.095	0.001	0.248	0.000
	Total Ct	1011					NS					665					784				
	Total Wt	6.90					NS					1.44					1.40				
Fall	Count	47	651	0	50	5	NS	NS	NS	NS	NS	41	951	2	85	8	46	572	1	23	2
	Fraction	0.062	0.865	0.000	0.066	0.007	NS	NS	NS	NS	NS	0.038	0.875	0.002	0.078	0.007	0.071	0.888	0.002	0.036	0.003
	Weight	0.391	0.231	0.000	0.379	2.784	NS	NS	NS	NS	NS	3.502	0.293	0.001	0.929	4.381	0.056	0.090	0.001	0.356	1.335
	Fraction	0.103	0.061	0.000	0.100	0.736	NS	NS	NS	NS	NS	0.385	0.032	0.000	0.102	0.481	0.030	0.049	0.001	0.194	0.727
	Total Ct	753					NS					1087					644				
	Total Wt	3.78					NS					9.11					1.84				

Table B-14 Count and weight (kg) by fish type for heat and pollution tolerant and intolerant fish sampled with bag seine at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream				Discharge				Thermally Exposed				Downstream			
		Heat		Pollution		Heat		Pollution		Heat		Pollution		Heat		Pollution	
		Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant
Winter	Count	85	0	188	0	NS	NS	NS	NS	73	0	584	0	18	0	165	0
	Fraction	0.114	0	0.252	0	NS	NS	NS	NS	0.086	0	0.689	0	0.066	0	0.604	0
	Weight	0.1055	0	0.0786	0	NS	NS	NS	NS	0.1358	0	0.0659	0	0.0479	0	0.0719	0
	Fraction	0.328	0	0.244	0	NS	NS	NS	NS	0.492	0	0.239	0	0.32	0	0.481	0
	Total Ct	745				NS				847				273			
	Total Wt	0.3216				NS				0.2761				0.1495			
Spring	Count	43	12	12	12	NS	NS	NS	NS	112	6	36	6	60	15	394	18
	Fraction	0.173	0.048	0.048	0.048	NS	NS	NS	NS	0.366	0.02	0.118	0.02	0.06	0.015	0.395	0.018
	Weight	0.0671	0.0114	0.0106	0.0114	NS	NS	NS	NS	0.3597	0.0049	0.0434	0.0049	1.2895	0.007	0.1985	0.0079
	Fraction	0.176	0.03	0.028	0.03	NS	NS	NS	NS	0.69	0.009	0.083	0.009	0.767	0.004	0.118	0.005
	Total Ct	248				NS				306				998			
	Total Wt	0.3823				NS				0.5212				1.6809			
Summer	Count	192	0	112	1	NS	NS	NS	NS	558	4	298	5	893	0	353	0
	Fraction	0.431	0	0.252	0.002	NS	NS	NS	NS	0.62	0.004	0.331	0.006	0.61	0	0.241	0
	Weight	0.8178	0	0.03191	0.0003	NS	NS	NS	NS	0.4936	0.0175	0.1214	0.0195	0.481	0	0.0678	0
	Fraction	0.889	0	0.035	0	NS	NS	NS	NS	0.729	0.026	0.179	0.029	0.768	0	0.108	0
	Total Ct	445				NS				900				1463			
	Total Wt	0.920311905				NS				0.6772				0.626			
Fall	Count	286	0	2695	1	NS	NS	NS	NS	294	0	188	1	89	0	307	1
	Fraction	0.076	0	0.713	0	NS	NS	NS	NS	0.413	0	0.264	0.001	0.099	0	0.34	0.001
	Weight	1.2608	0	0.1734	0.0011	NS	NS	NS	NS	0.4839	0	0.146	0.0114	0.1703	0	0.0682	0.0013
	Fraction	0.773	0	0.106	0.001	NS	NS	NS	NS	0.653	0	0.197	0.015	0.391	0	0.157	0.003
	Total Ct	3782				NS				712				902			
	Total Wt	1.6304				NS				0.7415				0.4353			

Table B-15 Count and weight (kg) by fish type for heat and pollution tolerant and intolerant fish sampled with electrofishing at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream				Discharge				Thermally Exposed				Downstream			
		Heat		Pollution		Heat		Pollution		Heat		Pollution		Heat		Pollution	
		Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant
Winter	Count	130	14	55	10	120	6	315	6	418	16	164	14	395	6	654	5
	Fraction	0.408	0.044	0.172	0.031	0.215	0.011	0.565	0.011	0.639	0.024	0.251	0.021	0.346	0.005	0.574	0.004
	Weight	143.674	4.841	104.65	0.333	133.732	1.5193	28.3706	1.5193	198.935	2.2476	126.16	1.38	123.805	0.6985	84.1013	0.2231
	Fraction	0.471	0.016	0.343	0.001	0.297	0.003	0.063	0.003	0.614	0.007	0.389	0.004	0.481	0.003	0.327	0.001
	Total Ct	319				558				654				1140			
	Total Wt	305.01				449.80				324.24				257.57			
Spring	Count	144	6	74	8	109	0	32	0	190	2	105	8	155	9	85	14
	Fraction	0.44	0.018	0.226	0.024	0.616	0	0.181	0	0.572	0.006	0.316	0.024	0.54	0.031	0.296	0.049
	Weight	116.204	0.3734	55.756	3.0137	105.841	0	35.0145	0	170.268	0.381	93.4924	14.692	123.247	0.352	86.391	8.133
	Fraction	0.449	0.001	0.216	0.012	0.449	0	0.148	0	0.612	0.001	0.336	0.053	0.574	0.002	0.402	0.038
	Total Ct	327				177				332				287			
	Total Wt	258.57				235.97				278.32				214.86			
Summer	Count	270	29	16	29	44	5	9	5	199	15	21	20	185	20	41	26
	Fraction	0.734	0.079	0.043	0.079	0.657	0.075	0.134	0.075	0.729	0.055	0.077	0.073	0.649	0.07	0.144	0.091
	Weight	59.0207	0.5297	24.2537	4.1308	19.134	0.183	6.979	0.183	92.2269	0.1061	34.2578	5.5521	57.964	0.571	34.113	4.721
	Fraction	0.503	0.005	0.207	0.035	0.597	0.006	0.218	0.006	0.528	0.001	0.196	0.032	0.48	0.005	0.283	0.039
	Total Ct	368				67				273				285			
	Total Wt	117.29				32.05				174.62				120.72			
Fall	Count	53	12	17	12	52	1	9	1	190	16	19	17	181	11	21	12
	Fraction	0.373	0.085	0.12	0.085	0.356	0.007	0.062	0.007	0.629	0.053	0.063	0.056	0.642	0.039	0.074	0.043
	Weight	67.476	0.591	31.714	0.591	59.945	0.02	34.877	0.02	107.78	0.637	42.314	0.849	87.9635	0.747	47.021	2.007
	Fraction	0.494	0.004	0.232	0.004	0.143	0	0.083	0	0.414	0.002	0.162	0.003	0.493	0.004	0.263	0.011
	Total Ct	142				146				302				282			
	Total Wt	136.73				418.43				260.56				178.59			

Table B-16 Count and weight (kg) by fish type for heat and pollution tolerant and intolerant fish sampled with hoop net at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream				Discharge				Thermally Exposed				Downstream			
		Heat		Pollution		Heat		Pollution		Heat		Pollution		Heat		Pollution	
		Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant
Winter	Count	2	1	1	18	NS	NS	NS	NS	1	4	0	26	5	8	0	19
	Fraction	0.071	0.036	0.036	0.643	NS	NS	NS	NS	0.028	0.111	0	0.722	0.156	0.25	0	0.594
	Weight	2.24	0.59	1.84	30.858	NS	NS	NS	NS	0.549	1.332	0	62.485	6.198	3.802	0	29.222
	Fraction	0.059	0.015	0.048	0.806	NS	NS	NS	NS	0.008	0.019	0	0.889	0.083	0.051	0	0.393
	Total Ct	28				NS				36				32			
	Total Wt	38.29				NS				70.30				74.43			
Spring	Count	11	0	6	4	NS	NS	NS	NS	18	0	8	3	15	0	1	5
	Fraction	0.216	0	0.118	0.078	NS	NS	NS	NS	0.5	0	0.222	0.083	0.263	0	0.018	0.088
	Weight	17.423	0	19.273	10.49	NS	NS	NS	NS	49.223	0	27.215	5.572	40.068	0	1.65	10.147
	Fraction	0.212	0	0.234	0.127	NS	NS	NS	NS	0.605	0	0.334	0.068	0.271	0	0.011	0.069
	Total Ct	51				NS				36				57			
	Total Wt	82.36				NS				81.40				147.99			
Summer	Count	19	0	1	9	NS	NS	NS	NS	8	0	1	3	15	0	3	3
	Fraction	0.452	0	0.024	0.214	NS	NS	NS	NS	0.381	0	0.048	0.143	0.484	0	0.097	0.097
	Weight	41.232	0	4.39	23.155	NS	NS	NS	NS	19.33	0	4.58	5.25	42.025	0	14.02	7.908
	Fraction	0.53	0	0.056	0.298	NS	NS	NS	NS	0.499	0	0.118	0.135	0.52	0	0.173	0.098
	Total Ct	42				NS				21				31			
	Total Wt	77.72				NS				38.76				80.82			
Fall	Count	1	1	3	1	NS	NS	NS	NS	19	2	1	2	8	6	5	9
	Fraction	0.033	0.033	0.1	0.033	NS	NS	NS	NS	0.559	0.059	0.029	0.059	0.205	0.154	0.128	0.231
	Weight	3.43	0.471	11.254	0.471	NS	NS	NS	NS	37.456	0.91	2.261	2.79	23.084	1.744	13.316	8.074
	Fraction	0.079	0.011	0.259	0.011	NS	NS	NS	NS	0.621	0.015	0.037	0.046	0.392	0.03	0.226	0.137
	Total Ct	30				NS				34				39			
	Total Wt	43.42				NS				60.36				58.96			

Table B-17 Count and weight (kg) by fish type for heat and pollution tolerant and intolerant fish sampled with Missouri mini-trawl at the LEC in 2017-2018, by season, and zone. NS indicated no sampling in the zone.

Season	Statistic	Upstream				Discharge				Thermally Exposed				Downstream			
		Heat		Pollution		Heat		Pollution		Heat		Pollution		Heat		Pollution	
		Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant	Tolerant	Intolerant
Winter	Count	55	0	4	0	NS	NS	NS	NS	59	0	14	0	38	0	5	0
	Fraction	0.223	0	0.016	0	NS	NS	NS	NS	0.182	0	0.043	0	0.102	0	0.013	0
	Weight	6.6586	0	4.881	0	NS	NS	NS	NS	9.2915	0	3.3295	0	3.9863	0	1.3635	0
	Fraction	0.665	0	0.487	0	NS	NS	NS	NS	0.895	0	0.321	0	0.433	0	0.148	0
	Total Ct	247				NS				325				371			
	Total Wt	10.01				NS				10.38				9.21			
Spring	Count	147	41	2	46	NS	NS	NS	NS	66	29	4	40	49	64	2	74
	Fraction	0.24	0.067	0.003	0.075	NS	NS	NS	NS	0.115	0.05	0.007	0.07	0.103	0.135	0.004	0.156
	Weight	0.333	0.0055	0.0019	0.0071	NS	NS	NS	NS	0.2867	0.0072	0.0024	0.0164	0.7896	0.0171	0.0005	1.3082
	Fraction	0.357	0.006	0.002	0.008	NS	NS	NS	NS	0.041	0.001	0	0.002	0.287	0.006	0	0.475
	Total Ct	613				NS				575				475			
	Total Wt	0.93				NS				7.07				2.75			
Summer	Count	277	8	73	9	NS	NS	NS	NS	149	7	53	7	241	11	33	11
	Fraction	0.274	0.008	0.072	0.009	NS	NS	NS	NS	0.224	0.011	0.08	0.011	0.307	0.014	0.042	0.014
	Weight	0.4563	0.0379	0.0171	0.041	NS	NS	NS	NS	0.9641	0.036	0.0135	0.036	0.6001	0.0387	0.017	0.0387
	Fraction	0.066	0.005	0.002	0.006	NS	NS	NS	NS	0.67	0.025	0.009	0.025	0.427	0.028	0.012	0.028
	Total Ct	1011				NS				665				784			
	Total Wt	6.90				NS				1.44				1.40			
Fall	Count	68	2	46	2	NS	NS	NS	NS	141	1	37	2	23	0	12	0
	Fraction	0.09	0.003	0.061	0.003	NS	NS	NS	NS	0.13	0.001	0.034	0.002	0.036	0	0.019	0
	Weight	0.0898	0.055	0.024	0.055	NS	NS	NS	NS	3.5932	0.029	1.211	0.0329	0.0481	0	0.007	0
	Fraction	0.024	0.015	0.006	0.015	NS	NS	NS	NS	0.395	0.003	0.133	0.004	0.026	0	0.004	0
	Total Ct	753				NS				1087				645			
	Total Wt	3.78				NS				9.11				1.84			

Table B-18 Means and standard errors for individual metrics, and standardized differences for winter fish sampling at the LEC in 2017-2018.

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Bag Seine	Density	Count	65.617	24.45	10	58.859	35.561	10	-0.157	18.447	5.833	10	-1.876
		Weight	0.026	0.009	10	0.017	0.009	10	-0.712	0.009	0.003	10	-1.704
	Diversity	^{0}D Ct	18	1.02	745	16	2.326	847	-0.788	15	1.049	273	-2.051
		^{1}D Ct	7.301	0.253	745	3.208	0.146	847	14.020	4.805	0.371	273	-5.568
		^{2}D Ct	5.779	0.176	745	2.03	0.077	847	-19.522	2.739	0.217	273	-10.873
		^{3}D Ct	5.316	0.162	745	1.759	0.058	847	-20.725	2.254	0.161	273	-13.404
	Heat Tolerance	Fraction Ct Intolerant	0	0	745	0	0	847		0	0	273	
		Fraction Wt Intolerant	0	0	745	0	0	847		0	0	273	
		Fraction Ct Tolerant	0.114	0.012	745	0.086	0.01	847	1.853	0.066	0.015	273	2.525
		Fraction Wt Tolerant	0.328	0.017	745	0.492	0.017	847	-6.746	0.32	0.028	273	0.242
	Composition	Fraction Ct Non-R	0.988	0.004	745	0.994	0.003	847	1.252	0.963	0.011	273	-2.066
		Fraction Wt Non-R	0.907	0.011	745	0.912	0.01	847	0.347	0.72	0.027	273	-6.408
	Pollution Tolerance	Fraction Ct Tolerant	0.252	0.016	745	0.689	0.016	847	-19.427	0.604	0.03	273	-10.475
		Fraction Wt Tolerant	0.244	0.016	745	0.239	0.015	847	0.233	0.481	0.03	273	-6.952
		Fraction Ct Intolerant	0	0	745	0	0	847		0	0	273	
		Fraction Wt Intolerant	0	0	745	0	0	847		0	0	273	
Electrofishing	Density	Count	17.003	3.899	18	32.697	7.083	18	1.941	58.332	30.2	18	1.357
		Weight	16.387	3.517	18	16.377	3.501	18	-0.002	12.524	2.49	18	-0.896
	Diversity	^{0}D Ct	28	2.486	319	30	3.441	654	0.471	31	2.842	1140	0.794
		^{1}D Ct	12.64	0.865	319	10.474	0.557	654	-2.104	6.237	0.304	1140	-6.982
		^{2}D Ct	8.676	0.691	319	7.129	0.333	654	-2.017	3.387	0.156	1140	-7.467
		^{3}D Ct	7.084	0.681	319	6.095	0.285	654	-1.340	2.721	0.117	1140	-6.314
	Heat Tolerance	Fraction Ct Intolerant	0.044	0.011	319	0.024	0.006	654	-1.545	0.005	0.002	1140	-3.341
		Fraction Wt Intolerant	0.016	0.007	319	0.007	0.003	654	-1.162	0.003	0.002	1140	-1.803
		Fraction Ct Tolerant	0.408	0.028	319	0.639	0.019	654	-6.934	0.346	0.014	1140	2.006
		Fraction Wt Tolerant	0.471	0.028	319	0.614	0.019	654	-4.229	0.481	0.015	1140	-0.316
	Composition	Fraction Ct Non-R	0.348	0.027	319	0.489	0.02	654	4.264	0.732	0.013	1140	12.920
		Fraction Wt Non-R	0.132	0.019	319	0.129	0.013	654	-0.130	0.273	0.013	1140	6.106
	Pollution Tolerance	Fraction Ct Tolerant	0.172	0.021	319	0.251	0.017	654	-2.916	0.574	0.015	1140	-15.637
		Fraction Wt Tolerant	0.343	0.027	319	0.389	0.019	654	-1.406	0.327	0.014	1140	0.533
		Fraction Ct Intolerant	0.031	0.01	319	0.021	0.006	654	-0.892	0.004	0.002	1140	-2.732
		Fraction Wt Intolerant	0.001	0.002	319	0.004	0.002	654	0.988	0.001	0.001	1140	0.000
Hoop net	Density	Count	1.459	0.766	18	2.021	1.015	18	0.442	1.803	0.697	18	0.332
		Weight	1.993	1.166	18	3.941	2.733	18	0.656	4.215	2.267	18	0.872
	Diversity	^{0}D Ct	8	1.87	28	7	1.067	36	-0.465	10	1.769	32	0.777
		^{1}D Ct	3.695	1.239	28	3.739	0.691	36	0.031	6.543	1.522	32	1.451
		^{2}D Ct	2.292	0.693	28	2.473	0.491	36	0.213	4.785	1.303	32	1.689
		^{3}D Ct	1.933	0.489	28	2.081	0.382	36	0.237	4	1.134	32	1.673
	Heat Tolerance	Fraction Ct Intolerant	0.036	0.035	28	0.111	0.052	36	1.189	0.25	0.077	32	2.540
		Fraction Wt Intolerant	0.015	0.023	28	0.019	0.023	36	0.124	0.051	0.039	32	0.797
		Fraction Ct Tolerant	0.071	0.049	28	0.028	0.027	36	0.771	0.156	0.064	32	-1.057
		Fraction Wt Tolerant	0.059	0.045	28	0.008	0.015	36	1.087	0.083	0.049	32	-0.363
	Composition	Fraction Ct Non-R	0.214	0.078	28	0.306	0.077	36	0.843	0.5	0.088	32	2.433
		Fraction Wt Non-R	0.107	0.058	28	0.111	0.052	36	0.051	0.563	0.088	32	4.328
	Pollution Tolerance	Fraction Ct Tolerant	0.036	0.035	28	0	0	36	1.023	0	0	32	1.023
		Fraction Wt Tolerant	0.048	0.04	28	0	0	36	1.188	0	0	32	1.188
		Fraction Ct Intolerant	0.643	0.091	28	0.722	0.075	36	0.673	0.594	0.087	32	-0.391
		Fraction Wt Intolerant	0.806	0.075	28	0.889	0.052	36	0.910	0.393	0.086	32	-3.617

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Missouri mini-trawl	Density	Count	11.109	2.859	24	12.315	3.113	24	0.285	18.091	4.884	24	1.234
		Weight	0.435	0.159	24	0.441	0.184	24	0.022	0.502	0.156	24	0.300
	Diversity	^{0}D Ct	16	1.449	247	19	1.22	325	1.584	22	2.346	371	2.176
		^{1}D Ct	8.237	0.525	247	7.688	0.523	325	-0.741	7.762	0.517	371	-0.646
		^{2}D Ct	6.386	0.373	247	5	0.369	325	-2.642	5.318	0.317	371	-2.183
		^{3}D Ct	5.78	0.333	247	4.197	0.314	325	-3.460	4.575	0.266	371	-2.828
	Heat Tolerance	Fraction Ct Intolerant	0	0	247	0	0	325		0	0	371	
		Fraction Wt Intolerant	0	0	247	0	0	325		0	0	371	
		Fraction Ct Tolerant	0.223	0.026	247	0.182	0.021	325	1.204	0.102	0.016	371	3.929
		Fraction Wt Tolerant	0.665	0.03	247	0.895	0.017	325	-6.664	0.433	0.026	371	5.867
	Composition	Fraction Ct Non-R	0.895	0.02	247	0.905	0.016	325	0.394	0.946	0.012	371	2.240
		Fraction Wt Non-R	0.252	0.028	247	0.051	0.012	325	-6.656	0.305	0.024	371	1.451
	Pollution Tolerance	Fraction Ct Tolerant	0.016	0.008	247	0.043	0.011	325	-1.957	0.013	0.006	371	0.303
		Fraction Wt Tolerant	0.487	0.032	247	0.321	0.026	325	4.047	0.148	0.018	371	9.222
		Fraction Ct Intolerant	0	0	247	0	0	325		0	0	371	
		Fraction Wt Intolerant	0	0	247	0	0	325		0	0	371	

Table B-19 Means and standard errors for individual metrics, and standardized differences for spring fish sampling at the LEC in 2017-2018.

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Bag Seine	Density	Count	25.575	12.97	6	26.577	3.428	6	0.075	136.66	79.08	6	1.386
		Weight	0.028	0.01	6	0.037	0.012	6	0.591	0.223	0.174	6	1.124
	Diversity	^0D Ct	20	1.731	248	23	1.503	306	1.309	28	1.903	998	3.110
		^1D Ct	7.595	0.62	248	10.897	0.622	306	3.761	5.775	0.258	998	-2.712
		^2D Ct	5.24	0.407	248	7.974	0.491	306	4.287	3.686	0.118	998	-3.666
		^3D Ct	4.546	0.343	248	6.954	0.461	306	4.193	3.268	0.091	998	-3.605
	Heat Tolerance	Fraction Ct Intolerant	0.048	0.014	248	0.02	0.008	306	-1.777	0.015	0.004	998	-2.339
		Fraction Wt Intolerant	0.03	0.011	248	0.009	0.005	306	-1.735	0.004	0.002	998	-2.360
		Fraction Ct Tolerant	0.173	0.024	248	0.366	0.028	306	-5.282	0.06	0.008	998	4.490
		Fraction Wt Tolerant	0.176	0.024	248	0.69	0.026	306	-14.345	0.767	0.013	998	-21.384
	Composition	Fraction Ct Non-R	0.895	0.019	248	0.81	0.022	306	-2.862	0.946	0.007	998	2.459
		Fraction Wt Non-R	0.662	0.03	248	0.879	0.019	306	6.138	0.245	0.014	998	-12.645
	Pollution Tolerance	Fraction Ct Tolerant	0.048	0.014	248	0.118	0.018	306	-3.057	0.395	0.015	998	-16.858
		Fraction Wt Tolerant	0.028	0.01	248	0.083	0.016	306	-2.905	0.118	0.01	998	-6.152
		Fraction Ct Intolerant	0.048	0.014	248	0.02	0.008	306	-1.777	0.018	0.004	998	-2.111
		Fraction Wt Intolerant	0.03	0.011	248	0.009	0.005	306	-1.735	0.005	0.002	998	-2.260
Electrofishing	Density	Count	15.945	1.772	18	16.461	2.983	18	0.149	14.891	2.799	18	-0.318
		Weight	12.555	1.23	18	13.655	2.832	18	0.356	11.068	1.677	18	-0.715
	Diversity	^0D Ct	33	2.362	327	27	1.227	332	-2.254	30	2.867	287	-0.808
		^1D Ct	17.23	1.08	327	16.325	0.854	332	-0.657	17.111	1.193	287	-0.074
		^2D Ct	12.863	0.83	327	11.776	0.913	332	-0.881	12.52	1.103	287	-0.248
		^3D Ct	11.202	0.793	327	9.506	0.931	332	-1.387	10.262	1.167	287	-0.667
	Heat Tolerance	Fraction Ct Intolerant	0.018	0.007	327	0.006	0.004	332	-1.414	0.031	0.01	287	1.032
		Fraction Wt Intolerant	0.001	0.002	327	0.001	0.002	332	0.000	0.002	0.003	287	0.316
		Fraction Ct Tolerant	0.44	0.027	327	0.572	0.027	332	-3.419	0.54	0.029	287	-2.485
		Fraction Wt Tolerant	0.449	0.028	327	0.612	0.027	332	-4.249	0.574	0.029	287	-3.117
	Composition	Fraction Ct Non-R	0.465	0.028	327	0.416	0.027	332	-1.268	0.484	0.029	287	0.470
		Fraction Wt Non-R	0.241	0.024	327	0.119	0.018	332	-4.124	0.146	0.021	287	-3.013
	Pollution Tolerance	Fraction Ct Tolerant	0.226	0.023	327	0.316	0.026	332	-2.613	0.296	0.027	287	-1.971
		Fraction Wt Tolerant	0.216	0.023	327	0.336	0.026	332	-3.479	0.402	0.029	287	-5.052
		Fraction Ct Intolerant	0.024	0.008	327	0.024	0.008	332	0.000	0.049	0.013	287	1.634
		Fraction Wt Intolerant	0.012	0.006	327	0.053	0.012	332	2.995	0.038	0.011	287	2.033
Hoop net	Density	Count	2.859	0.603	18	2.028	0.475	18	-1.081	3.204	1.424	18	0.223
		Weight	4.61	1.24	18	4.579	1.373	18	-0.017	8.292	3.775	18	0.927
	Diversity	^0D Ct	8	0.72	51	11	1.475	36	1.828	11	1.319	57	1.996
		^1D Ct	6.602	0.581	51	8.937	1.345	36	1.594	5.911	0.956	57	-0.617
		^2D Ct	5.767	0.624	51	7.807	1.359	36	1.364	3.747	0.723	57	-2.115
		^3D Ct	5.282	0.639	51	7.106	1.368	36	1.208	3.006	0.582	57	-2.634
	Heat Tolerance	Fraction Ct Intolerant	0	0	51	0	0	36		0	0	57	
		Fraction Wt Intolerant	0	0	51	0	0	36		0	0	57	
		Fraction Ct Tolerant	0.216	0.058	51	0.5	0.083	36	-2.803	0.263	0.058	57	-0.573
		Fraction Wt Tolerant	0.212	0.057	51	0.605	0.081	36	-3.947	0.271	0.059	57	-0.719
	Composition	Fraction Ct Non-R	0.49	0.07	51	0.306	0.077	36	-1.771	0.684	0.062	57	2.081
		Fraction Wt Non-R	0.422	0.069	51	0.25	0.072	36	-1.721	0.707	0.06	57	3.106
	Pollution Tolerance	Fraction Ct Tolerant	0.118	0.045	51	0.222	0.069	36	-1.258	0.018	0.018	57	2.062
		Fraction Wt Tolerant	0.234	0.059	51	0.334	0.079	36	-1.016	0.011	0.014	57	3.663
		Fraction Ct Intolerant	0.078	0.038	51	0.083	0.046	36	0.084	0.088	0.038	57	0.188
		Fraction Wt Intolerant	0.127	0.047	51	0.068	0.042	36	-0.941	0.069	0.034	57	-1.010

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Missouri mini-trawl	Density	Count	25.002	7.217	24	20.608	6.262	24	-0.460	22.727	5.832	24	-0.245
		Weight	0.04	0.017	24	0.277	0.117	24	2.008	0.133	0.069	24	1.304
	Diversity	^0D Ct	28	3.414	613	31	1.762	575	0.781	28	2.463	475	0.000
		^1D Ct	10.629	0.536	613	10.371	0.588	575	-0.324	11.041	0.573	475	0.525
		^2D Ct	8.006	0.373	613	6.504	0.412	575	-2.703	8.224	0.391	475	0.403
		^3D Ct	7.01	0.399	613	5.181	0.365	575	-3.381	7.237	0.409	475	0.396
	Heat Tolerance	Fraction Ct Intolerant	0.067	0.01	613	0.05	0.009	575	-1.251	0.135	0.016	475	3.646
		Fraction Wt Intolerant	0.006	0.003	613	0.001	0.001	575	-1.477	0.006	0.004	475	0.000
		Fraction Ct Tolerant	0.24	0.017	613	0.115	0.013	575	5.738	0.103	0.014	475	6.176
		Fraction Wt Tolerant	0.357	0.019	613	0.041	0.008	575	15.016	0.287	0.021	475	2.467
	Composition	Fraction Ct Non-R	0.597	0.02	613	0.63	0.02	575	1.168	0.878	0.015	475	11.304
		Fraction Wt Non-R	0.854	0.014	613	0.846	0.015	575	-0.386	0.277	0.021	475	-23.080
	Pollution Tolerance	Fraction Ct Tolerant	0.003	0.002	613	0.007	0.003	575	-0.971	0.004	0.003	475	-0.275
		Fraction Wt Tolerant	0.002	0.002	613	0	0	575	1.108	0	0	475	1.108
		Fraction Ct Intolerant	0.075	0.011	613	0.07	0.011	575	-0.332	0.156	0.017	475	4.100
		Fraction Wt Intolerant	0.008	0.004	613	0.002	0.002	575	-1.481	0.475	0.023	475	20.135

Table B-20 Means and standard errors for individual metrics, and standardized differences for summer fish sampling at the LEC in 2017-2018.

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Bag Seine	Density	Count	70.61	25.49	8	74.97	35.238	8	0.100	155.06	51.87	8	1.461
		Weight	0.152	0.096	8	0.053	0.019	8	-1.008	0.057	0.016	8	-0.972
	Diversity	^{0}D Ct	15	1.41	445	15	1.932	900	0.000	26	1.738	1463	4.915
		^{1}D Ct	7.246	0.32	445	3.883	0.114	900	-9.903	5.842	0.182	1463	-3.815
		^{2}D Ct	5.754	0.246	445	3.356	0.05	900	-9.553	4.219	0.099	1463	-5.791
		^{3}D Ct	5.246	0.246	445	3.265	0.04	900	-7.956	3.837	0.09	1463	-5.389
	Heat Tolerance	Fraction Ct Intolerant	0	0	445	0.004	0.002	900	1.901	0	0	1463	
		Fraction Wt Intolerant	0	0	445	0.026	0.005	900	4.901	0	0	1463	
		Fraction Ct Tolerant	0.431	0.023	445	0.62	0.016	900	-6.629	0.61	0.013	1463	-6.700
		Fraction Wt Tolerant	0.889	0.015	445	0.729	0.015	900	7.617	0.768	0.011	1463	6.528
	Composition	Fraction Ct Non-R	0.8	0.019	445	0.7	0.015	900	-4.107	0.629	0.013	1463	-7.506
		Fraction Wt Non-R	0.142	0.017	445	0.497	0.017	900	15.116	0.333	0.012	1463	9.258
	Pollution Tolerance	Fraction Ct Tolerant	0.252	0.021	445	0.331	0.016	900	-3.053	0.241	0.011	1463	0.470
		Fraction Wt Tolerant	0.035	0.009	445	0.179	0.013	900	-9.311	0.108	0.008	1463	-6.131
		Fraction Ct Intolerant	0.002	0.002	445	0.006	0.003	900	1.200	0	0	1463	-0.944
		Fraction Wt Intolerant	0	0	445	0.029	0.006	900	5.185	0	0	1463	
Electrofishing	Density	Count	17.396	4.278	18	14.163	3.611	18	-0.577	15.146	4.092	18	-0.380
		Weight	5.584	1.184	18	8.501	1.441	18	1.564	6.198	0.795	18	0.431
	Diversity	^{0}D Ct	29	1.824	368	30	3.183	273	0.273	23	1.753	285	-2.372
		^{1}D Ct	11.579	0.781	368	13.721	1.166	273	1.526	11.685	0.821	285	0.093
		^{2}D Ct	6.214	0.57	368	8.011	0.904	273	1.682	6.972	0.734	285	0.815
		^{3}D Ct	4.586	0.437	368	5.849	0.717	273	1.505	5.174	0.598	285	0.793
	Heat Tolerance	Fraction Ct Intolerant	0.079	0.014	368	0.055	0.014	273	-1.218	0.07	0.015	285	-0.436
		Fraction Wt Intolerant	0.005	0.004	368	0.001	0.002	273	-0.965	0.005	0.004	285	0.000
		Fraction Ct Tolerant	0.734	0.023	368	0.729	0.027	273	0.141	0.649	0.028	285	2.331
		Fraction Wt Tolerant	0.503	0.026	368	0.528	0.03	273	-0.627	0.48	0.03	285	0.583
	Composition	Fraction Ct Non-R	0.391	0.025	368	0.359	0.029	273	-0.829	0.375	0.029	285	-0.417
		Fraction Wt Non-R	0.157	0.019	368	0.306	0.028	273	4.418	0.244	0.025	285	2.742
	Pollution Tolerance	Fraction Ct Tolerant	0.043	0.011	368	0.077	0.016	273	-1.762	0.144	0.021	285	-4.329
		Fraction Wt Tolerant	0.207	0.021	368	0.196	0.024	273	0.344	0.283	0.027	285	-2.233
		Fraction Ct Intolerant	0.079	0.014	368	0.073	0.016	273	-0.284	0.091	0.017	285	0.543
		Fraction Wt Intolerant	0.035	0.01	368	0.032	0.011	273	-0.209	0.039	0.011	285	0.268
Hoop net	Density	Count	2.379	0.621	18	1.193	0.351	18	-1.663	1.759	0.447	18	-0.810
		Weight	4.376	1.303	18	2.204	0.788	18	-1.426	4.57	1.28	18	0.106
	Diversity	^{0}D Ct	11	1.515	42	9	1.48	21	-0.944	11	1.525	31	0.000
		^{1}D Ct	7.537	1.181	42	7.734	1.414	21	0.107	9.139	1.372	31	0.885
		^{2}D Ct	5.959	1.017	42	7	1.382	21	0.606	8.076	1.338	31	1.259
		^{3}D Ct	5.292	0.916	42	6.594	1.349	21	0.799	7.462	1.31	31	1.358
	Heat Tolerance	Fraction Ct Intolerant	0	0	42	0	0	21		0	0	31	
		Fraction Wt Intolerant	0	0	42	0	0	21		0	0	31	
		Fraction Ct Tolerant	0.452	0.077	42	0.381	0.106	21	0.543	0.484	0.09	31	-0.271
		Fraction Wt Tolerant	0.53	0.077	42	0.499	0.109	21	0.232	0.52	0.09	31	0.085
	Composition	Fraction Ct Non-R	0.381	0.075	42	0.286	0.099	21	-0.767	0.323	0.084	31	-0.515
		Fraction Wt Non-R	0.245	0.066	42	0.143	0.076	21	-1.008	0.212	0.073	31	-0.333
	Pollution Tolerance	Fraction Ct Tolerant	0.024	0.024	42	0.048	0.047	21	-0.459	0.097	0.053	31	-1.255
		Fraction Wt Tolerant	0.056	0.035	42	0.118	0.07	21	-0.786	0.173	0.068	31	-1.527
		Fraction Ct Intolerant	0.214	0.063	42	0.143	0.076	21	-0.716	0.097	0.053	31	-1.416
		Fraction Wt Intolerant	0.298	0.071	42	0.135	0.075	21	-1.588	0.098	0.053	31	-2.260

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Missouri mini-trawl	Density	Count	43.595	10.07	24	26.836	7.79	24	-1.317	36.29	10.01	24	-0.515
		Weight	0.286	0.198	24	0.054	0.028	24	-1.158	0.065	0.023	24	-1.106
	Diversity	^{0}D Ct	28	2.125	1011	21	1.483	665	-2.701	22	1.935	784	-2.088
		^{1}D Ct	10.711	0.345	1011	11.189	0.392	665	0.916	9.737	0.354	784	-1.971
		^{2}D Ct	8.337	0.267	1011	9.064	0.419	665	1.465	7.34	0.318	784	-2.403
		^{3}D Ct	7.411	0.303	1011	7.922	0.461	665	0.927	6.299	0.316	784	-2.541
	Heat Tolerance	Fraction Ct Intolerant	0.008	0.003	1011	0.011	0.004	665	0.610	0.014	0.004	784	1.189
		Fraction Wt Intolerant	0.005	0.002	1011	0.025	0.006	665	3.102	0.028	0.006	784	3.653
		Fraction Ct Tolerant	0.274	0.014	1011	0.224	0.016	665	2.336	0.307	0.016	784	-1.525
		Fraction Wt Tolerant	0.066	0.008	1011	0.67	0.018	665	-30.450	0.427	0.018	784	-18.691
	Composition	Fraction Ct Non-R	0.736	0.014	1011	0.821	0.015	665	4.182	0.853	0.013	784	6.235
		Fraction Wt Non-R	0.253	0.014	1011	0.335	0.018	665	3.589	0.343	0.017	784	4.132
	Pollution Tolerance	Fraction Ct Tolerant	0.072	0.008	1011	0.08	0.011	665	-0.602	0.042	0.007	784	2.769
		Fraction Wt Tolerant	0.002	0.001	1011	0.009	0.004	665	-1.785	0.012	0.004	784	-2.418
		Fraction Ct Intolerant	0.009	0.003	1011	0.011	0.004	665	0.399	0.014	0.004	784	0.973
		Fraction Wt Intolerant	0.006	0.002	1011	0.025	0.006	665	2.913	0.028	0.006	784	3.452

Table B-21 Means and standard errors for individual metrics, and standardized differences for fall fish sampling at the LEC in 2017-2018.

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Bag Seine	Density	Count	250.49	100	8	63.844	22.776	8	-1.819	121.46	68.44	8	-1.064
		Weight	0.143	0.077	8	0.063	0.018	8	-1.006	0.059	0.028	8	-1.017
	Diversity	^{0}D Ct	22	1.812	3782	18	1.607	712	-1.651	20	1.33	902	-0.890
		^{1}D Ct	2.971	0.06	3782	6.139	0.232	712	13.223	7.78	0.268	902	17.479
		^{2}D Ct	1.899	0.031	3782	4.505	0.173	712	14.799	5.592	0.235	902	15.580
		^{3}D Ct	1.673	0.024	3782	3.961	0.164	712	13.797	4.723	0.236	902	12.884
	Heat Tolerance	Fraction Ct Intolerant	0	0	3782	0	0	712		0	0	902	
		Fraction Wt Intolerant	0	0	3782	0	0	712		0	0	902	
		Fraction Ct Tolerant	0.076	0.004	3782	0.413	0.018	712	-17.785	0.099	0.01	902	-2.122
		Fraction Wt Tolerant	0.773	0.007	3782	0.653	0.018	712	6.284	0.391	0.016	902	21.683
	Composition	Fraction Ct Non-R	0.976	0.002	3782	0.938	0.009	712	-4.054	0.973	0.005	902	-0.505
		Fraction Wt Non-R	0.37	0.008	3782	0.63	0.018	712	13.182	0.657	0.016	902	16.262
	Pollution Tolerance	Fraction Ct Tolerant	0.713	0.007	3782	0.264	0.017	712	24.830	0.34	0.016	902	21.432
		Fraction Wt Tolerant	0.106	0.005	3782	0.197	0.015	712	-5.787	0.157	0.012	902	-3.891
		Fraction Ct Intolerant	0	0	3782	0.001	0.001	712	0.844	0.001	0.001	902	0.950
		Fraction Wt Intolerant	0.001	0.001	3782	0.015	0.005	712	3.054	0.003	0.002	902	1.057
Electrofishing	Density	Count	8.079	1.526	17	15.72	3.28	18	2.112	14.455	3.614	18	1.625
		Weight	7.977	1.428	17	13.58	3.15	18	1.620	9.312	2.725	18	0.434
	Diversity	^{0}D Ct	23	2.165	142	24	2.025	302	0.337	22	1.314	282	-0.395
		^{1}D Ct	11.75	1.454	142	11.634	0.823	302	-0.069	9.008	0.694	282	-1.702
		^{2}D Ct	6.642	1.149	142	7.699	0.683	302	0.791	5.23	0.491	282	-1.129
		^{3}D Ct	4.829	0.873	142	6.116	0.621	302	1.202	4.113	0.391	282	-0.749
	Heat Tolerance	Fraction Ct Intolerant	0.085	0.023	142	0.053	0.013	302	-1.198	0.039	0.012	282	-1.763
		Fraction Wt Intolerant	0.004	0.005	142	0.002	0.003	302	-0.340	0.004	0.004	282	0.000
		Fraction Ct Tolerant	0.373	0.041	142	0.629	0.028	302	-5.204	0.642	0.029	282	-5.421
		Fraction Wt Tolerant	0.494	0.042	142	0.414	0.028	302	1.580	0.493	0.03	282	0.019
	Composition	Fraction Ct Non-R	0.246	0.036	142	0.248	0.025	302	0.046	0.145	0.021	282	-2.417
		Fraction Wt Non-R	0.131	0.028	142	0.185	0.022	302	1.497	0.14	0.021	282	0.257
	Pollution Tolerance	Fraction Ct Tolerant	0.12	0.027	142	0.063	0.014	302	1.860	0.074	0.016	282	1.464
		Fraction Wt Tolerant	0.232	0.035	142	0.162	0.021	302	1.696	0.263	0.026	282	-0.703
		Fraction Ct Intolerant	0.085	0.023	142	0.056	0.013	302	-1.079	0.043	0.012	282	-1.595
		Fraction Wt Intolerant	0.004	0.005	142	0.003	0.003	302	-0.162	0.011	0.006	282	0.858
Hoop net	Density	Count	1.678	0.579	18	1.904	0.647	18	0.261	2.313	0.491	18	0.837
		Weight	2.423	1.055	18	3.377	1.661	18	0.485	3.451	0.978	18	0.715
	Diversity	^{0}D Ct	8	1.43	30	13	1.626	34	2.309	11	1.369	39	1.516
		^{1}D Ct	4.911	1.029	30	9.448	1.539	34	2.451	8.758	1.125	39	2.523
		^{2}D Ct	3.543	0.817	30	7.41	1.437	34	2.339	7.567	1.089	39	2.956
		^{3}D Ct	2.991	0.697	30	6.466	1.319	34	2.330	6.936	1.078	39	3.074
	Heat Tolerance	Fraction Ct Intolerant	0.033	0.033	30	0.059	0.04	34	0.501	0.154	0.058	39	1.823
		Fraction Wt Intolerant	0.011	0.019	30	0.015	0.021	34	0.142	0.03	0.027	39	0.571
		Fraction Ct Tolerant	0.033	0.033	30	0.559	0.085	34	-5.769	0.205	0.065	39	-2.376
		Fraction Wt Tolerant	0.079	0.049	30	0.621	0.083	34	-5.606	0.392	0.078	39	-3.388
	Composition	Fraction Ct Non-R	0.7	0.084	30	0.235	0.073	34	-4.195	0.538	0.08	39	-1.401
		Fraction Wt Non-R	0.652	0.087	30	0.142	0.06	34	-4.831	0.464	0.08	39	-1.592
	Pollution Tolerance	Fraction Ct Tolerant	0.1	0.055	30	0.029	0.029	34	1.148	0.128	0.053	39	-0.366
		Fraction Wt Tolerant	0.259	0.08	30	0.037	0.032	34	2.573	0.226	0.067	39	0.316
		Fraction Ct Intolerant	0.033	0.033	30	0.059	0.04	34	0.501	0.231	0.067	39	2.642
		Fraction Wt Intolerant	0.011	0.019	30	0.046	0.036	34	0.861	0.137	0.055	39	2.163

Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
			Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Missouri mini-trawl	Density	Count	32.089	13.85	24	42.259	19.095	24	0.431	32.149	19.89	24	0.002
		Weight	0.147	0.054	24	0.363	0.183	24	1.127	0.07	0.049	24	-1.061
	Diversity	^{0}D Ct	15	1.026	753	22	1.692	1087	3.538	18	1.418	645	1.714
		^{1}D Ct	5.439	0.222	753	6.194	0.223	1087	2.395	5.664	0.256	645	0.662
		^{2}D Ct	3.718	0.156	753	4.574	0.129	1087	4.238	4.129	0.149	645	1.905
		^{3}D Ct	3.192	0.139	753	4.196	0.101	1087	5.839	3.755	0.13	645	2.957
	Heat Tolerance	Fraction Ct Intolerant	0.003	0.002	753	0.001	0.001	1087	-0.904	0	0	645	-1.505
		Fraction Wt Intolerant	0.015	0.004	753	0.003	0.002	1087	-2.537	0	0	645	-3.386
		Fraction Ct Tolerant	0.09	0.01	753	0.13	0.01	1087	-2.742	0.036	0.007	645	4.235
		Fraction Wt Tolerant	0.024	0.006	753	0.395	0.015	1087	-23.419	0.026	0.006	645	-0.238
	Composition	Fraction Ct Non-R	0.938	0.009	753	0.962	0.006	1087	2.279	0.929	0.01	645	-0.672
		Fraction Wt Non-R	0.897	0.011	753	0.615	0.015	1087	-15.282	0.97	0.007	645	5.635
	Pollution Tolerance	Fraction Ct Tolerant	0.061	0.009	753	0.034	0.005	1087	2.619	0.019	0.005	645	4.099
		Fraction Wt Tolerant	0.006	0.003	753	0.133	0.01	1087	-11.895	0.004	0.002	645	0.533
		Fraction Ct Intolerant	0.003	0.002	753	0.002	0.001	1087	-0.415	0	0	645	-1.505
		Fraction Wt Intolerant	0.015	0.004	753	0.004	0.002	1087	-2.279	0	0	645	-3.386

Table B-22 Summary of benthic invertebrates collected in Hester-Dendy bottom samples at the LEC during 2017-2018 sampling, by season and zone.

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Cli-Tubi-Naididae	Stylaria lacustris	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Slavina appendiculata	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Pristina longiseta	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cli-Tubi-Naididae	Piguetiella sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Paranais sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Nais pardalis	1	5	4	7	0	0	0	0	0	0	0	0	1	0	0	0
Cli-Tubi-Naididae	Nais communis/variabilis complex	0	4	6	8	0	0	0	0	1	0	0	0	0	0	2	0
Cli-Tubi-Naididae	Nais behningi	0	16	4	0	2	0	1	12	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Nais sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Limnodrilus claparedianus/cervix	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0
Cli-Tubi-Naididae	Dero digitata	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	2
Cli-Tubi-Naididae	Naidinae	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Tubificinae	32	0	7	2	2	0	2	0	0	0	1	0	0	0	0	0
Cli-Hiru-Glossiphoniidae	Helobdella austinensis	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Cli- -	Clitellata	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0
Ins-Tric-Polycentropodidae	Neureclipsis sp.	1	2	2	0	60	0	49	38	23	0	16	3	8	0	18	2
Ins-Tric-Polycentropodidae	Cyrnellus fraternus	0	0	0	0	0	0	1	0	23	0	4	12	0	0	1	0
Ins-Tric-Polycentropodidae	Polycentropodidae	0	1	0	0	7	0	1	0	1	0	2	1	0	0	1	0
Ins-Tric-Leptoceridae	Nectopsyche sp.	0	0	0	0	0	0	1	0	2	0	1	0	0	0	1	0
Ins-Tric-Leptoceridae	Leptoceridae	0	0	0	0	1	0	0	0	3	0	1	0	0	0	0	0
Ins-Tric-Hydroptilidae	Mayatrichia sp.	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Ins-Tric-Hydroptilidae	Hydroptilidae	0	0	0	1	0	0	0	0	0	2	1	0	0	0	0	0
Ins-Tric-Hydropsychidae	Potamyia flava	10	46	57	20	388	222	327	691	344	690	705	64	104	344	186	75
Ins-Tric-Hydropsychidae	Hydropsyche sp.	14	67	34	16	925	754	890	1119	400	1619	1750	24	30	188	85	33
Ins-Tric-Hydropsychidae	Cheumatopsyche sp.	1	0	0	0	8	0	14	2	0	0	0	0	0	0	0	0
Ins-Tric-Hydropsychidae	Hydropsychidae	2	7	7	7	640	792	129	308	78	229	163	20	38	44	42	12
Ins-Tric-	Trichoptera	0	0	0	0	11	8	0	0	2	0	2	1	0	0	0	0
Ins-Plec-Taeniopterygidae	Taeniopteryx sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ins-Plec-Taeniopterygidae	Taeniopterygidae	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Plec-Perlodidae	Isoperla sp.	2	2	0	2	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Plec-Perlodidae	Hydroperla sp.	3	3	6	1	0	0	0	0	0	0	0	0	3	8	6	1
Ins-Plec-Perlodidae	Perlodidae	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	1
Ins-Plec-Perlidae	Perlinella sp.	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0
Ins-Plec-Perlidae	Perlesta sp.	0	2	0	0	11	4	14	18	0	0	1	0	0	0	0	0
Ins-Plec-Perlidae	Neoperla sp.	1	1	3	2	2	0	2	6	9	0	20	5	8	1	11	3

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Plec-Perlidae	Attaneuria sp.	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	1
Ins-Plec-Perlidae	Acroneuria sp.	2	0	1	6	5	0	2	1	21	8	6	6	2	0	2	1
Ins-Plec-Perlidae	Perlidae	0	4	0	1	4	0	4	1	0	0	2	1	0	0	0	0
Ins-Plec-	Plecoptera	0	1	0	0	1	0	0	0	0	0	16	0	1	1	4	0
Ins-Odon-Gomphidae	Gomphus sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Odon-Gomphidae	Dromogomphus sp.	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Ins-Odon-Gomphidae	Gomphidae	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Ins-Odon-Corduliidae	Neurocordulia molesta	1	0	0	2	0	0	0	0	15	0	5	4	0	0	6	4
Ins-Odon-Corduliidae	Didymops transversa	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0
Ins-Odon-Coenagrionidae	Argia sp.	0	0	0	2	1	0	4	0	15	0	38	19	1	0	12	6
Ins-Odon-	Zygoptera	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Mega-Corydalidae	Corydalus sp.	0	0	0	2	0	0	0	0	27	10	2	2	1	0	0	0
Ins-Mega-Corydalidae	Chauliodes sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Ephe-Potamanthidae	Anthopotamus sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Ephe-Polymitarcyidae	Ephoron album	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
Ins-Ephe-Polymitarcyidae	Ephoron sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Ephe-Palingeniidae	Pentagenia vittigera	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Ins-Ephe-Leptohyphidae	Tricorythodes sp.	0	0	1	0	15	2	10	12	7	2	4	3	0	2	0	0
Ins-Ephe-Isonychiidae	Isonychia sicca	0	0	0	0	11	0	13	0	0	0	2	0	0	0	0	0
Ins-Ephe-Isonychiidae	Isonychia rufa	0	0	0	0	7	6	26	0	11	0	1	2	0	4	0	0
Ins-Ephe-Isonychiidae	Isonychia bicolor	0	0	0	0	1	6	18	0	16	0	16	1	0	0	0	0
Ins-Ephe-Isonychiidae	Isonychia sp.	0	0	0	0	133	14	116	29	18	0	1	2	0	0	0	0
Ins-Ephe-Heptageniidae	Stenacron sp.	0	0	0	1	2	0	0	0	4	0	1	1	0	0	1	2
Ins-Ephe-Heptageniidae	Maccaffertium terminatum	0	2	1	1	4	0	0	4	2	0	1	0	0	0	0	0
Ins-Ephe-Heptageniidae	Maccaffertium mexicanum integrum	11	9	23	10	99	22	71	76	119	30	154	77	131	54	157	93
Ins-Ephe-Heptageniidae	Maccaffertium sp.	2	0	4	2	8	0	1	5	2	0	0	2	7	2	3	0
Ins-Ephe-Heptageniidae	Heptagenia sp.	0	4	4	0	43	0	22	15	0	5	17	1	7	23	6	7
Ins-Ephe-Heptageniidae	Heptageniidae	8	2	7	8	122	20	48	95	53	27	95	25	27	3	39	12
Ins-Ephe-Ephemeridae	Hexagenia sp.	0	0	0	0	0	0	0	0	1	0	4	0	0	0	1	0
Ins-Ephe-Ephemeridae	Ephemeridae	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Ins-Ephe-Caenidae	Caenis sp.	0	0	0	0	22	0	21	27	28	2	36	14	1	0	0	0
Ins-Ephe-Caenidae	Amercaenis sp.	0	0	0	0	224	180	47	525	46	8	19	18	0	0	0	0
Ins-Ephe-Caenidae	Caenidae	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0	0
Ins-Ephe-Baetidae	Pseudocloeon sp.	0	0	0	0	469	262	281	346	93	159	86	31	0	0	0	0
Ins-Ephe-Baetidae	Baetidae	0	0	0	0	150	40	55	119	2	2	3	35	0	0	0	0
Ins-Ephe-	Ephemeroptera	0	1	0	0	21	4	3	8	0	0	0	2	1	0	0	0
Ins-Dipt-Tabanidae	Tabanidae	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Dipt-Chironomidae	Tvetenia vitracies	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tribelos fuscicorne	0	0	0	0	0	0	0	0	7	0	2	10	0	0	0	0
Ins-Dipt-Chironomidae	Tribelos sp.	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0
Ins-Dipt-Chironomidae	Thienemannimyia sp. group	0	2	0	2	3	0	7	4	5	0	15	14	5	0	13	4
Ins-Dipt-Chironomidae	Thienemanniella xena	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Thienemanniella lobapodema	0	0	0	0	8	0	2	0	2	0	0	0	0	0	1	0
Ins-Dipt-Chironomidae	Thienemanniella sp.	0	2	4	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Telopelopia okoboji	7	6	13	5	22	0	22	8	7	0	28	0	1	0	2	0
Ins-Dipt-Chironomidae	Tanytarsus sepp	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanytarsus glabrescens group	0	3	1	2	5	0	2	8	9	0	6	6	0	1	1	0
Ins-Dipt-Chironomidae	Tanytarsus sp.	3	4	1	4	0	0	0	0	4	0	1	0	0	0	0	0
Ins-Dipt-Chironomidae	Stenochironomus sp.	0	0	0	0	255	92	134	148	616	76	683	813	0	0	0	0
Ins-Dipt-Chironomidae	Robackia claviger	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Rheotanytarsus exiguus group	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Rheotanytarsus sp.	0	30	49	8	523	116	246	664	1749	524	1193	99	1	1	6	4
Ins-Dipt-Chironomidae	Procladius (Psilotanypus) sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Procladius sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum scalaenum group	0	2	0	0	6	0	14	8	77	0	50	58	0	0	0	1
Ins-Dipt-Chironomidae	Polypedilum illinoense group	0	0	1	2	0	0	0	0	16	0	10	0	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum halterale group	0	0	0	0	0	0	0	0	1	0	16	1	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum flavum	0	22	22	7	239	104	235	429	67	145	94	83	4	3	9	6
Ins-Dipt-Chironomidae	Polypedilum sp.	0	2	1	1	1	4	0	0	195	4	21	13	0	2	0	0
Ins-Dipt-Chironomidae	Phaenopsectra obediens group	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Dipt-Chironomidae	Paralauterborniella nigrohaltera	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Paracladopelma sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Parachironomus frequens	0	0	0	0	0	0	0	0	13	0	0	5	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladius sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius minimus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius distinctus	0	7	8	16	0	0	0	0	0	0	0	2	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius crassicornus/rectine	0	1	0	3	0	0	0	0	2	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius alternantherae	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius sp.	0	6	0	4	0	0	0	0	0	0	0	1	0	0	1	1
Ins-Dipt-Chironomidae	Labrundinia pilosella	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Kribiodorum perpulchrum	0	0	0	0	8	0	4	4	14	4	11	24	0	0	0	0
Ins-Dipt-Chironomidae	Hydrobaenus sp.	2	1	0	1	0	0	0	0	0	0	0	0	1	0	0	2
Ins-Dipt-Chironomidae	Harnischia sp.	1	0	0	0	6	0	2	0	7	0	12	3	0	0	0	0
Ins-Dipt-Chironomidae	Glyptotendipes sp.	0	0	4	0	0	0	0	0	0	0	4	1	0	0	0	1

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Dipt-Chironomidae	Dicrotendipes neomodestus	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Dicrotendipes sp.	2	2	0	0	4	0	0	0	5	0	1	4	0	0	0	0
Ins-Dipt-Chironomidae	Cryptotendipes sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cryptochironomus sp.	0	0	0	0	7	0	0	0	2	0	1	1	0	0	6	0
Ins-Dipt-Chironomidae	Cricotopus/Orthocladius sp.	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Corynoneura lobata	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Corynoneura floridaensis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cladotanytarsus sp. group A	0	0	0	0	4	0	0	0	2	0	1	0	0	0	0	0
Ins-Dipt-Chironomidae	Chironomus decorus group	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Chironomus sp.	0	0	0	0	0	0	0	0	9	0	0	2	0	0	5	1
Ins-Dipt-Chironomidae	Axarus sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia mallochi	2	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia (Ablabesmyia)	0	0	0	0	0	0	0	0	74	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia (Karelia) sp.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia sp.	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Ins-Dipt-Chironomidae	Chironomidae	0	1	7	4	18	0	32	40	136	20	45	217	0	1	1	3
Ins-Dipt-Chironomidae	Chironominae	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Chironominae (Chironomini)	0	0	0	0	8	0	2	0	68	0	2	8	0	0	0	0
Ins-Dipt-Chironomidae	Chironominae (Tanytarsini)	0	0	1	0	0	4	7	18	64	16	0	2	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladiinae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanypodinae	0	1	0	0	4	0	0	0	0	0	0	4	0	0	1	0
Ins-Dipt-Chaoboridae	Chaoborus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ins- -	Insecta	0	0	0	0	0	0	0	195	65	0	138	90	0	0	0	0
Ara-Trom-Hydrachnidia	Hydracarina	0	0	0	0	2	0	0	0	0	2	0	1	0	1	0	1
Hyd-Anth-Hydridae	Hydra sp.	1	0	5	7	0	0	0	0	0	0	2	0	1	0	0	0
Gas-Baso-Physidae	Physa sp.	0	0	2	2	0	0	0	0	0	0	0	1	0	0	2	0
Gas-Baso-Ancylidae	Ferrissia sp.	5	2	0	3	0	0	0	0	0	0	1	0	0	0	0	0
Biv-Vene-Dreissenidae	Dreissena polymorpha	0	0	0	0	0	0	0	0	4	0	15	3	0	0	1	1
Biv-Vene-Corbiculidae	Corbicula fluminea	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
Tre-Neoo-Planariidae	Planariidae	0	1	0	0	0	0	2	0	6	0	7	43	0	2	1	1
Tre- -	Trepaxonemata	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Table B-23 Summary of benthic invertebrates collected in Hester-Dendy mid-depth samples at the LEC during 2017-2018 sampling, by season and zone.

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Cli-Tubi-Naididae	Stylaria lacustris	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Slavina appendiculata	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Piguetiella sp.	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Paranais sp.	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Nais pardalis	0	5	0	2	0	0	0	0	0	0	0	1	0	0	0	0
Cli-Tubi-Naididae	Nais communis/variabilis complex	3	6	18	4	0	0	0	0	0	0	1	0	0	0	0	0
Cli-Tubi-Naididae	Nais behningi	0	28	5	0	5	0	8	8	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Nais sp.	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Limnodrilus udekemianus	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Cli-Tubi-Naididae	Limnodrilus claparedianus/cervix	0	0	0	2	0	0	0	0	0	0	0	2	3	0	0	0
Cli-Tubi-Naididae	Dero digitata	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Cli-Tubi-Naididae	Aulodrilus pluriseta	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Tubificinae	8	0	11	9	0	0	0	0	0	0	0	11	2	1	0	0
Cli- -	Clitellata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ins-Tric-Polycentropodidae	Neureclipsis sp.	1	0	5	1	31	2	21	26	16	0	9	0	12	0	27	1
Ins-Tric-Polycentropodidae	Cyrnellus fraternus	0	0	0	0	3	0	0	0	3	0	2	3	0	0	2	6
Ins-Tric-Polycentropodidae	Polycentropodidae	0	0	0	0	0	0	2	0	4	0	3	1	0	0	0	0
Ins-Tric-Leptoceridae	Nectopsyche sp.	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Ins-Tric-Leptoceridae	Leptoceridae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Tric-Hydroptilidae	Mayatrichia sp.	0	0	0	0	11	0	2	11	2	0	0	2	0	0	0	0
Ins-Tric-Hydroptilidae	Hydroptilidae	0	0	0	0	2	0	2	1	0	0	0	0	0	0	0	0
Ins-Tric-Hydropsychidae	Potamyia flava	8	37	38	23	446	253	230	631	202	391	458	41	149	65	277	211
Ins-Tric-Hydropsychidae	Hydropsyche sp.	18	91	38	16	1673	1674	1187	1356	398	2228	1372	16	72	254	115	93
Ins-Tric-Hydropsychidae	Cheumatopsyche sp.	0	0	0	0	17	4	3	8	0	0	0	0	1	0	2	1
Ins-Tric-Hydropsychidae	Hydropsychidae	4	8	4	8	497	258	251	435	61	210	190	23	70	14	6	8
Ins-Tric-	Trichoptera	0	0	0	0	2	0	0	4	0	2	1	1	0	0	0	0
Ins-Plec-Taeniopterygidae	Taeniopteryx sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3
Ins-Plec-Taeniopterygidae	Strophopteryx sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Plec-Perlodidae	Isoperla sp.	17	1	20	10	0	0	0	0	0	0	0	0	2	1	0	0
Ins-Plec-Perlodidae	Hydroperla sp.	1	4	28	5	0	0	0	0	0	0	0	0	0	7	5	7
Ins-Plec-Perlodidae	Perlodidae	0	0	1	0	0	0	0	0	0	0	0	0	2	1	2	1
Ins-Plec-Perlidae	Perlesta sp.	0	0	0	0	34	34	17	36	0	0	0	0	0	0	0	0
Ins-Plec-Perlidae	Neoperla sp.	0	0	0	0	4	0	0	2	10	0	4	9	3	1	9	9
Ins-Plec-Perlidae	Attaneuria sp.	0	0	1	0	1	0	0	3	1	8	6	1	1	0	1	2
Ins-Plec-Perlidae	Acroneuria sp.	4	0	1	1	4	0	5	1	15	0	10	1	1	1	3	3

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Plec-Perlidae	Perlidae	0	1	0	0	4	2	2	0	0	0	2	0	0	1	2	1
Ins-Plec-	Plecoptera	0	0	1	0	1	0	0	0	0	0	0	0	0	1	4	0
Ins-Odon-Gomphidae	Dromogomphus sp.	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ins-Odon-Gomphidae	Gomphidae	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Ins-Odon-Corduliidae	Neurocordulia molesta	0	0	1	1	3	0	0	3	12	0	4	7	1	0	1	4
Ins-Odon-Corduliidae	Didymops transversa	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Odon-Corduliidae	Didymops sp.	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Ins-Odon-Corduliidae	Macromiinae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Odon-Coenagrionidae	Coenagrion/Enallagma sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Odon-Coenagrionidae	Argia sp.	1	0	0	3	2	0	3	0	9	0	11	10	0	0	8	7
Ins-Odon-Coenagrionidae	Coenagrionidae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Odon-	Zygoptera	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Ins-Mega-Corydalidae	Corydalus sp.	0	0	0	0	0	0	0	4	8	0	12	5	0	0	1	0
Ins-Mega-Corydalidae	Chauliodes sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ins-Ephe-Potamanthidae	Anthopotamus sp.	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Ephe-Leptohyphidae	Tricorythodes sp.	0	0	0	0	15	2	2	12	23	2	15	8	0	0	1	1
Ins-Ephe-Leptohyphidae	Leptohyphidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Ephe-Isonychiidae	Isonychia sicca	0	0	0	0	3	14	5	8	0	0	1	0	0	0	0	0
Ins-Ephe-Isonychiidae	Isonychia rufa	0	0	0	0	43	10	17	13	4	0	1	2	1	0	0	0
Ins-Ephe-Isonychiidae	Isonychia bicolor	0	0	0	0	22	0	13	1	2	10	1	0	0	0	0	0
Ins-Ephe-Isonychiidae	Isonychia sp.	0	0	0	0	116	32	53	55	11	2	2	1	0	0	2	0
Ins-Ephe-Heptageniidae	Stenonema femoratum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Ephe-Heptageniidae	Stenacron sp.	1	0	0	4	0	0	1	0	7	0	0	2	2	0	2	1
Ins-Ephe-Heptageniidae	Spinadis simplex	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Ins-Ephe-Heptageniidae	Raptoheptagenia cruentata	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Ephe-Heptageniidae	Maccaffertium terminatum	1	0	4	0	0	0	1	6	1	0	1	1	0	0	0	0
Ins-Ephe-Heptageniidae	Maccaffertium mexicanum integrum	50	7	58	25	185	26	87	111	238	55	213	225	206	52	245	190
Ins-Ephe-Heptageniidae	Maccaffertium exiguum	0	0	0	0	2	0	1	4	1	0	0	0	0	0	0	0
Ins-Ephe-Heptageniidae	Maccaffertium sp.	1	2	5	4	0	0	5	2	4	0	19	0	1	0	4	2
Ins-Ephe-Heptageniidae	Heptagenia sp.	7	10	7	6	39	34	27	62	4	20	0	0	6	16	17	10
Ins-Ephe-Heptageniidae	Heptageniidae	10	2	13	13	138	26	80	152	154	22	82	79	48	18	80	63
Ins-Ephe-Ephemeridae	Hexagenia limbata	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ins-Ephe-Ephemeridae	Hexagenia sp.	2	0	0	0	12	0	0	0	1	0	1	0	0	0	0	0
Ins-Ephe-Caenidae	Caenis sp.	0	0	0	0	9	0	12	42	59	4	30	18	2	0	0	1
Ins-Ephe-Caenidae	Amercaenis sp.	0	0	0	0	354	388	212	483	22	12	21	11	0	0	0	0
Ins-Ephe-Caenidae	Caenidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Ephe-Baetidae	Pseudocloeon sp.	0	0	0	0	536	372	272	474	252	294	206	94	0	0	0	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Ephe-Baetidae	Baetidae	0	0	0	1	236	68	90	165	11	20	37	21	0	0	0	0
Ins-Ephe-	Ephemeroptera	0	0	0	0	11	52	1	12	2	4	0	0	0	0	0	0
Ins-Dipt-Simuliidae	Simulium sp.	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Empididae	Hemerodromia sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tribelos fuscicorne	0	0	0	0	0	0	0	0	12	0	0	4	0	0	0	0
Ins-Dipt-Chironomidae	Thienemannimyia sp. group	2	0	2	5	10	0	11	6	11	0	5	16	2	0	1	5
Ins-Dipt-Chironomidae	Thienemanniella xena	0	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Thienemanniella lobapodema	0	0	0	0	4	0	0	0	4	0	0	2	0	0	1	0
Ins-Dipt-Chironomidae	Telopelopia okoboji	16	5	11	4	2	0	2	2	25	1	38	1	0	0	0	0
Ins-Dipt-Chironomidae	Tanytarsus sepp	0	0	0	0	0	0	2	0	8	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanytarsus glabrescens group	1	0	0	0	2	0	1	1	6	0	10	6	0	1	0	0
Ins-Dipt-Chironomidae	Tanytarsus sp.	5	0	8	5	4	0	0	0	0	0	8	2	0	0	0	0
Ins-Dipt-Chironomidae	Stenochironomus sp.	0	0	0	0	176	54	112	138	395	26	664	738	0	0	0	0
Ins-Dipt-Chironomidae	Rheotanytarsus sp.	0	44	31	11	557	184	363	578	1930	481	2413	166	1	9	3	4
Ins-Dipt-Chironomidae	Polypedilum scalaenum group	0	0	1	0	12	0	0	4	85	0	53	74	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum illinoense group	0	7	1	5	0	0	0	0	5	0	16	15	0	0	0	1
Ins-Dipt-Chironomidae	Polypedilum halterale group	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum flavum	3	24	16	10	294	228	158	297	234	136	354	72	2	9	6	8
Ins-Dipt-Chironomidae	Polypedilum sp.	0	0	0	0	0	0	1	0	32	0	3	19	0	0	0	0
Ins-Dipt-Chironomidae	Phaenopsectra obediens	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Paratanytarsus sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Dipt-Chironomidae	Paralauterborniella nigrohaltera	4	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Dipt-Chironomidae	Parachironomus frequens	0	0	0	0	0	0	0	0	0	0	4	17	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladius (Orthocladius)	1	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladius sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius distinctus	8	12	10	4	0	0	0	0	0	0	12	2	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius crassicornus/rectine	0	0	5	1	0	0	1	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius alternantherae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nanocladius sp.	0	0	7	2	0	0	0	0	0	0	0	0	0	0	0	2
Ins-Dipt-Chironomidae	Micropsectra sp.	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Kribiodorum perpulchrum	0	0	0	0	8	0	0	2	7	0	9	17	0	0	0	0
Ins-Dipt-Chironomidae	Hydrobaenus sp.	3	0	4	3	0	0	0	0	0	0	0	0	0	0	0	2
Ins-Dipt-Chironomidae	Harnischia sp.	0	0	1	3	0	0	1	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Glyptotendipes sp.	0	0	0	0	0	0	0	0	2	0	21	3	0	0	0	0
Ins-Dipt-Chironomidae	Eukiefferiella claripennis group	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Dicrotendipes neomodestus	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Dicrotendipes sp.	0	2	0	0	0	0	0	0	9	0	1	3	0	0	0	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Dipt-Chironomidae	Cryptochironomus sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cricotopus/Orthocladius sp.	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0
Ins-Dipt-Chironomidae	Cricotopus sylvestris group	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cricotopus bicinctus	0	13	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cricotopus sp.	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Corynoneura lobata	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Corynoneura sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cladotanytarsus sp. group A	0	0	0	0	0	0	0	0	2	0	2	2	0	0	0	0
Ins-Dipt-Chironomidae	Chironomus decorus group	0	0	1	0	0	0	0	8	0	0	0	2	0	0	0	0
Ins-Dipt-Chironomidae	Chironomus sp.	0	0	0	1	0	0	0	0	4	0	0	1	0	0	0	2
Ins-Dipt-Chironomidae	Ablabesmyia mallochi	1	0	0	0	0	0	0	0	1	0	8	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia annulata	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1
Ins-Dipt-Chironomidae	Ablabesmyia (Ablabesmyia)	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia (Karelia) sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Chironomidae	1	0	4	1	22	8	6	16	78	24	39	151	0	0	2	1
Ins-Dipt-Chironomidae	Chironominae	0	0	0	0	2	0	5	0	0	0	0	1	0	0	0	0
Ins-Dipt-Chironomidae	Chironominae (Chironomini)	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Ins-Dipt-Chironomidae	Chironominae (Tanytarsini)	0	0	0	0	2	12	11	13	17	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladiinae	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanypodinae	0	0	0	1	0	0	0	0	8	0	0	0	0	0	2	0
Ins-Dipt-Chaoboridae	Chaoborus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ins-Dipt-Ceratopogonidae	Sphaeromias sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Ceratopogonidae	Bezzia/Palpomyia sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Cole-Elmidae	Macronychus glabratus	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Cole-Elmidae	Ancyronyx variegatus	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Ins- -	Insecta	0	0	0	0	0	0	0	0	107	42	112	118	0	0	0	0
Ara-Trom-Hydrachnidia	Hydracarina	0	0	2	0	4	2	0	2	0	0	0	0	1	0	0	0
Hyd-Anth-Hydridae	Hydra sp.	0	0	4	2	0	0	0	0	0	0	0	0	0	0	1	1
Gas-Baso-Physidae	Physa sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas-Baso-Ancylidae	Ferrissia sp.	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Biv-Vene-Dreissenidae	Dreissena polymorpha	1	0	0	0	0	0	0	0	5	0	4	2	0	0	0	0
Biv-Vene-Corbiculidae	Corbicula fluminea	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Tre-Neoo-Planariidae	Planariidae	0	0	0	1	0	0	0	0	5	8	4	13	1	4	1	0

Table B-24 Summary of benthic invertebrates collected in Ponar samples at the LEC during 2017-2018 sampling, by season and zone.

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Cli-Tubi-Naididae	Quistadrilus multisetosus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Pristina synclites	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Cli-Tubi-Naididae	Piguetiella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cli-Tubi-Naididae	Paranais sp.	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Nais pardalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cli-Tubi-Naididae	Nais communis/variabilis complex	0	0	0	208	0	0	0	0	0	0	0	0	0	0	0	2
Cli-Tubi-Naididae	Nais behningi	0	20	16	1	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Limnodrilus udekemianus	4	0	2	6	0	0	0	15	71	0	2	68	10	5	2	1
Cli-Tubi-Naididae	Limnodrilus hoffmeisteri	18	1	15	37	0	0	2	9	4	0	5	2	11	1	10	8
Cli-Tubi-Naididae	Limnodrilus hoffmeisteri complex	56	8	0	16	64	0	14	60	0	0	96	72	0	1	16	0
Cli-Tubi-Naididae	Limnodrilus claparedianus/cervix	224	1	147	249	38	5	11	110	527	0	111	438	28	1	131	56
Cli-Tubi-Naididae	Limnodrilus sp.	4	0	3	5	0	0	1	2	5	0	1	1	8	3	9	15
Cli-Tubi-Naididae	Dero digitata	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	4
Cli-Tubi-Naididae	Dero sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Cli-Tubi-Naididae	Branchiura sowerbyi	29	1	42	25	83	8	21	55	264	1	160	333	352	9	111	226
Cli-Tubi-Naididae	Aulodrilus pluriseta	0	0	1	0	0	0	0	4	0	0	0	0	0	0	0	16
Cli-Tubi-Naididae	Naididae	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	8
Cli-Tubi-Naididae	Naidinae	1	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0
Cli-Tubi-Naididae	Tubificinae	871	56	669	564	488	87	196	376	891	9	432	319	1403	41	691	648
Cli-Lumb-Lumbriculidae	Lumbriculidae	0	0	0	0	3	0	2	6	0	0	0	0	1	0	1	4
Cli-Hiru-Glossiphoniidae	Helobdella papillata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Cli-Hiru-Glossiphoniidae	Helobdella sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Cli-Hiru-Glossiphoniidae	Actinobdella inequiannulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cli-Hiru-Glossiphoniidae	Actinobdella sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Cli- -	Clitellata	334	6	773	883	40	14	79	171	209	0	85	128	404	18	232	256
Ins-Tric-Polycentropodidae	Neureclipsis sp.	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0
Ins-Tric-Polycentropodidae	Cyrnellus fraternus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ins-Tric-Leptoceridae	Oecetis sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Tric-Hydroptilidae	Hydroptila sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Tric-Hydropsychidae	Potamyia flava	1	1	0	4	2	4	1	1	14	6	10	3	6	3	10	21
Ins-Tric-Hydropsychidae	Hydropsyche sp.	0	1	4	6	36	25	28	21	45	12	4	5	3	16	8	11
Ins-Tric-Hydropsychidae	Hydropsychidae	0	0	0	0	2	0	8	2	6	2	3	0	1	2	1	2
Ins-Tric-	Trichoptera	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Ins-Plec-Taeniopterygidae	Taeniopteryx sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Plec-Perlodidae	Isoperla sp.	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Plec-Perlodidae	Perlodidae	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Plec-Perlidae	Neoperla sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ins-Plec-	Plecoptera	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Ins-Odon-Gomphidae	Gomphus sp.	0	0	0	1	1	1	1	3	1	0	0	2	3	1	5	3
Ins-Odon-Gomphidae	Dromogomphus sp.	0	0	2	4	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Odon-Gomphidae	Gomphidae	0	0	1	2	0	1	0	0	0	0	0	4	0	0	0	0
Ins-Odon-Corduliidae	Neurocordulia molesta	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
Ins-Odon-Corduliidae	Didymops transversa	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Mega-Corydalidae	Corydalus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Lepi-	Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Hemi-Corixidae	Corixidae	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Hemi-Aphididae	Aphididae	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Ins-Hemi-	Hemiptera	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Ephe-Polymitarcyidae	Tortopus primus	0	0	0	0	19	0	6	2	0	0	0	0	0	0	0	0
Ins-Ephe-Polymitarcyidae	Ephoron album	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Ephe-Polymitarcyidae	Ephoron sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Ins-Ephe-Polymitarcyidae	Polymitarcidae	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0
Ins-Ephe-Palingeniidae	Pentagenia vittigera	3	25	7	1	1	0	10	2	89	4	67	163	22	68	1	23
Ins-Ephe-Leptohyphidae	Tricorythodes sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Ephe-Isonychiidae	Isonychia sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Ins-Ephe-Heptageniidae	Maccaffertium mexicanum integrum	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	1
Ins-Ephe-Heptageniidae	Heptageniidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ins-Ephe-Ephemeridae	Hexagenia limbata	39	0	27	45	23	0	10	16	234	0	78	105	105	3	82	64
Ins-Ephe-Ephemeridae	Hexagenia bilineata	0	0	0	0	13	0	4	18	71	0	10	13	0	0	0	0
Ins-Ephe-Ephemeridae	Hexagenia atrocaudata	1	0	0	1	0	0	0	0	29	0	2	2	2	0	6	1
Ins-Ephe-Ephemeridae	Hexagenia sp.	59	0	21	14	3	0	0	0	374	0	106	99	38	0	22	24
Ins-Ephe-Ephemeridae	Ephemeridae	8	0	8	14	2	0	0	2	12	0	31	12	4	0	2	0
Ins-Ephe-Caenidae	Caenis sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ins-Ephe-Caenidae	Amercaenis sp.	0	0	0	0	0	0	0	3	0	0	1	1	0	0	0	0
Ins-Ephe-Caenidae	Caenidae	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
Ins-Ephe-Baetidae	Pseudocloeon sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Ins-Ephe-Baetidae	Baetidae	0	0	0	0	0	0	0	1	0	0	0	2	1	0	0	0
Ins-Ephe-	Ephemeroptera	5	0	9	2	0	0	5	2	0	0	2	0	0	0	0	0
Ins-Dipt-Simuliidae	Simuliidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Psychodidae	Psychoda sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Dipt-Psychodidae	Psychodidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	3
Ins-Dipt-Dolichopodidae	Dolichopodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Dipt-Chironomidae	Tribelos jucundus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tribelos fuscicorne	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tribelos ater	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Thienemannimyia sp. group	0	0	0	2	0	0	0	4	2	0	0	0	0	0	0	3
Ins-Dipt-Chironomidae	Telopelopia okoboji	0	0	1	0	1	0	0	32	1	0	1	5	0	0	0	3
Ins-Dipt-Chironomidae	Tanytarsus sepp	0	0	1	2	5	0	0	2	0	0	0	0	0	0	0	2
Ins-Dipt-Chironomidae	Tanytarsus sp.	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanypus neopunctipennis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Stictochironomus caffrarius grou	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Dipt-Chironomidae	Stictochironomus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Dipt-Chironomidae	Stenochironomus sp.	0	0	0	0	2	0	2	0	6	0	0	0	0	0	0	1
Ins-Dipt-Chironomidae	Stempellinella leptocelloides	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Robackia claviger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Dipt-Chironomidae	Rheotanytarsus sp.	0	1	0	0	17	1	1	52	41	6	9	13	0	0	1	1
Ins-Dipt-Chironomidae	Rheosmittia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ins-Dipt-Chironomidae	Procladius (Psilotanypus) sp.	19	0	13	17	4	0	5	8	4	0	0	0	0	3	0	8
Ins-Dipt-Chironomidae	Procladius (Holotanypus) sp.	20	0	8	7	8	0	2	2	0	0	0	0	0	0	3	6
Ins-Dipt-Chironomidae	Procladius sp.	9	0	4	0	0	0	0	2	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum trigonus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ins-Dipt-Chironomidae	Polypedilum scalaenum group	0	0	0	0	0	1	0	0	9	0	48	2	0	0	2	1
Ins-Dipt-Chironomidae	Polypedilum nubifer	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Polypedilum illinoense group	0	1	0	18	16	0	1	0	3	0	4	0	0	0	1	2
Ins-Dipt-Chironomidae	Polypedilum halterale group	1	15	1	5	3	5	1	36	4	0	5	1	0	0	0	1
Ins-Dipt-Chironomidae	Polypedilum flavum	2	0	0	4	1	3	6	6	32	0	8	4	0	0	1	0
Ins-Dipt-Chironomidae	Polypedilum sp.	0	2	0	0	0	1	0	0	1	0	4	0	0	0	0	0
Ins-Dipt-Chironomidae	Paratendipes basidens	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	3
Ins-Dipt-Chironomidae	Paralauterborniella nigrohaltera	4	7	1	0	0	1	0	0	0	0	0	0	0	0	2	0
Ins-Dipt-Chironomidae	Paracladopelma undine	3	0	1	4	1	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Paracladopelma nereis	1	1	1	5	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Paracladopelma sp.	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Parachironomus frequens	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladius (Orthocladius)	1	1	2	10	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Orthocladius sp.	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Nilotanypus sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Kribiodorum perpulchrum	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Hydrobaenus sp.	18	0	3	7	0	0	0	0	0	0	0	0	0	0	1	5
Ins-Dipt-Chironomidae	Harnischia sp.	1	5	1	0	100	2	14	70	4	0	17	4	2	0	0	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins-Dipt-Chironomidae	Glyptotendipes sp.	1	0	1	0	4	0	0	0	0	0	0	0	0	0	1	0
Ins-Dipt-Chironomidae	Epoicocladius sp.	2	0	1	1	0	0	1	5	1	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Dicrotendipes sp.	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Demicryptochironomus sp.	6	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cryptotendipes sp.	0	1	0	1	20	0	7	7	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Cryptochironomus sp.	15	3	8	4	30	3	6	58	25	0	27	21	120	2	36	44
Ins-Dipt-Chironomidae	Cricotopus/Orthocladius sp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Dipt-Chironomidae	Cricotopus sp.	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Dipt-Chironomidae	Coelotanypus sp.	0	1	1	3	0	0	0	0	0	0	0	1	0	0	2	2
Ins-Dipt-Chironomidae	Chironomus decorus group	7	0	6	13	139	0	68	135	0	0	10	30	18	0	0	1
Ins-Dipt-Chironomidae	Chironomus sp.	0	0	3	3	106	0	10	29	3	0	12	28	0	0	38	14
Ins-Dipt-Chironomidae	Chernovskiia sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
Ins-Dipt-Chironomidae	Axarus sp.	0	0	0	0	1	0	0	0	6	0	0	3	6	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia mallochi	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia annulata	2	0	1	2	7	0	2	8	1	0	21	5	18	0	15	8
Ins-Dipt-Chironomidae	Ablabesmyia (Karelia) sp.	2	0	2	1	0	0	0	8	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Ablabesmyia sp.	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Ins-Dipt-Chironomidae	Chironomidae	14	0	4	2	15	1	3	4	0	0	3	0	0	0	0	3
Ins-Dipt-Chironomidae	Chironominae	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Chironominae (Chironomini)	3	3	1	2	3	0	0	1	1	0	0	0	0	0	0	2
Ins-Dipt-Chironomidae	Orthocladiinae	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanypodinae	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0
Ins-Dipt-Chironomidae	Tanypus sp.	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Ins-Dipt-Chaoboridae	Chaoborus sp.	1	0	0	1	0	0	0	0	1	0	0	0	0	0	9	6
Ins-Dipt-Chaoboridae	Chaoboridae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Ins-Dipt-Ceratopogonidae	Stilobezzia sp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Dipt-Ceratopogonidae	Sphaeromias sp.	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1
Ins-Dipt-Ceratopogonidae	Probezzia sp.	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
Ins-Dipt-Ceratopogonidae	Culicoides sp.	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	2
Ins-Dipt-Ceratopogonidae	Ceratopogon sp.	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Ceratopogonidae	Bezzia/Palpomyia sp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ins-Dipt-Ceratopogonidae	Ceratopogonidae	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Ins-Dipt-	Diptera	0	0	0	0	0	0	30	0	1	0	1	0	0	1	0	0
Ins-Cole-Staphylinidae	Staphylinidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ins-Cole-Elmidae	Stenelmis sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ins-Cole-Elmidae	Dubiraphia sp.	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1
Ins-Cole-	Coleoptera	2	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0

Class-Order-Family	Name	Winter				Spring				Summer				Fall			
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Ins- -	Insecta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Ent-Coll-Isotomidae	Isotomidae	44	0	2	1	0	0	0	0	1	0	0	0	0	0	1	6
Ara-Trom-Hydrachnidia	Hydracarina	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Gas-Baso-Planorbidae	Planorbidae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Gas-Baso-Ancylidae	Ancylidae	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biv-Vene-Dreissenidae	Dreissena polymorpha	4	0	0	5	0	0	0	0	1	0	0	8	2	0	1	1
Biv-Vene-Corbiculidae	Corbicula fluminea	2	6	2	2	1	0	1	0	13	0	3	2	0	2	1	2
Biv-Unio-Unionidae	Leptodea fragilis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Biv- -	Bivalvia	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Table B-25 Mean density, standard error, and sample size for benthic inverebrate sampline at the LEC in 2017-2018, by gear, season and zone.

Gear	Season	Statistic	Zone			
			Upstream Reference	Discharge	Thermally Exposed	Downstream
Hester-Dendy	Winter	Mean	19.59	103.77	40.07	23.12
		Std Err	2.24	26.79	8.57	3.54
		N	23	8	24	24
	Spring	Mean	601.73	1251.47	605.28	776.26
		Std Err	90.27	281.60	128.19	122.51
		N	23	7	14	18
	Summer	Mean	546.10	1298.97	687.73	246.14
		Std Err	195.54	496.67	271.02	40.49
		N	23	8	24	22
	Fall	Mean	56.28	196.58	84.25	55.99
		Std Err	15.19	74.48	16.84	8.52
		N	24	8	24	23
Ponar	Winter	Mean	199.25	56.09	195.51	238.68
		Std Err	49.39	13.78	64.23	84.92
		N	6	2	6	6
	Spring	Mean	140.17	52.24	60.58	146.15
		Std Err	39.81	0.96	17.49	39.25
		N	6	2	6	6
	Summer	Mean	321.90	13.46	148.40	204.38
		Std Err	107.99	8.97	48.76	46.63
		N	6	2	6	6
	Fall	Mean	275.11	58.97	157.59	164.64
		Std Err	64.00	1.28	45.56	39.81
		N	6	2	6	6

Table B-26 Sample size, estimated diversity and standard deviation at q = 0, 1, 2, and 3 for benthic invertebrate sampling at the LEC in 2017-2018, by gear, season, and zone.

Gear	Season	Statistic	Upstream		Discharge		Thermally Exposed		Downstream	
			Estimate	StdDev	Estimate	StdDev	Estimate	StdDev	Estimate	StdDev
Hester-Dendy	Winter	N	248	-	558	-	602	-	324	-
		^0D	42	3.16	37	2.14	49	2.7	49	3.47
		^1D	17.32	1.54	12.15	0.67	17.41	0.88	25.94	1.59
		^2D	9.64	1.04	7.26	0.46	11.23	0.59	17.1	1.28
		^3D	7.29	0.89	5.82	0.42	9.51	0.5	13.63	1.16
	Spring	N	6853	-	5051	-	5275	-	8523	-
		^0D	48	1.55	17	0.76	42	2.05	41	1.83
		^1D	8.1	0.12	5.5	0.09	8.24	0.15	8.32	0.09
		^2D	5.01	0.09	3.61	0.07	4.95	0.1	6.17	0.07
		^3D	4.05	0.08	2.94	0.06	3.91	0.09	5.38	0.08
	Summer	N	7900	-	6962	-	11048	-	3085	-
		^0D	55	1.76	20	0.86	56	2.78	56	3.62
		^1D	7.58	0.13	4.13	0.05	6.92	0.09	7.81	0.23
		^2D	3.93	0.07	2.8	0.04	4.63	0.05	3.6	0.11
		^3D	3.09	0.05	2.38	0.03	4.07	0.04	2.78	0.07
	Fall	N	788	-	1055	-	1281	-	835	-
		^0D	33	3.43	18	1.71	39	2.69	35	2.99
		^1D	4.93	0.25	3.92	0.13	6.06	0.24	6.22	0.31
		^2D	3.29	0.11	2.96	0.07	3.91	0.11	3.9	0.14
		^3D	2.97	0.09	2.74	0.06	3.49	0.09	3.48	0.11
Ponar	Winter	N	556	-	107	-	330	-	738	-
		^0D	42	3.13	25	2.87	36	2.91	45	3.19
		^1D	10.14	0.63	11.73	1.15	9.25	0.82	9.27	0.52
		^2D	5.02	0.35	7.8	0.82	4.35	0.41	4.86	0.23
		^3D	3.81	0.26	6.56	0.76	3.31	0.29	4.03	0.17
	Spring	N	653	-	59	-	232	-	763	-
		^0D	36	3.12	12	1.7	29	2.11	40	2.54
		^1D	13.63	0.62	6.89	1.02	13.24	1	15.52	0.6
		^2D	9.23	0.48	4.46	0.81	7.86	0.85	10.98	0.46
		^3D	7.71	0.44	3.53	0.69	5.91	0.74	9.36	0.46
	Summer	N	1513	-	31	-	705	-	1318	-
		^0D	35	2.88	7	0.93	27	1.76	32	1.77
		^1D	8.66	0.27	4.95	0.64	10.87	0.43	7.42	0.23
		^2D	5.36	0.19	4.09	0.63	7.89	0.33	4.93	0.15
		^3D	4.4	0.17	3.66	0.63	6.87	0.33	4.24	0.13
	Fall	N	717	-	119	-	514	-	563	-
		^0D	23	1.91	16	1.74	41	3.5	49	3.58
		^1D	5.61	0.27	5.17	0.65	10.39	0.6	11.03	0.75
		^2D	3.39	0.17	2.81	0.35	6.57	0.35	5.11	0.36
		^3D	2.81	0.14	2.3	0.26	5.62	0.3	3.84	0.26

Table B-27 Fraction of organisms in major groups during benthic sampling at the LEC in 2017-2018, by gear and zone.

Gear	Major Group	Zone			
		Upstream Reference	Discharge	Thermally Exposed	Downstream
Hester-Dendy	Trichoptera	0.3317	0.6676	0.4281	0.3471
	Diptera	0.4063	0.1594	0.3703	0.3420
	Ephemeroptera	0.2328	0.1571	0.1650	0.2584
	Plecoptera	0.0099	0.0066	0.0112	0.0099
	Tubificida	0.0038	0.0043	0.0042	0.0048
	Other	0.0084	0.0027	0.0122	0.0260
Ponar	Trichoptera	0.0134	0.1277	0.0150	0.0115
	Diptera	0.1089	0.1436	0.1001	0.1208
	Ephemeroptera	0.1324	0.1791	0.0992	0.0911
	Plecoptera	0.0002	0.0000	0.0004	0.0007
	Tubificida	0.6222	0.4610	0.5567	0.5624
	Other	0.1126	0.0674	0.2222	0.2038

Table B-28 Number of species and fraction of organism in EPT orders during benthic sampling at the LEC in 2017-2018 by gear, season, and zone.

Gear	Season	Statistic	Zone			
			Upstream Reference	Discharge	Thermally Exposed	Downstream
Hester-Dendy	Winter	# Species	14	11	14	16
		Fraction	0.559	0.525	0.536	0.489
		N	329	606	702	405
	Spring	# Species	27	13	23	22
		Fraction	0.778	0.874	0.771	0.742
		N	10103	6395	6186	10200
	Summer	# Species	21	12	22	19
		Fraction	0.309	0.8	0.483	0.231
		N	9169	7586	12049	3953
	Fall	# Species	17	11	19	16
		Fraction	0.966	0.969	0.931	0.913
		N	986	1148	1476	940
Ponar	Winter	# Species	5	3	4	7
		Fraction	0.063	0.154	0.042	0.041
		N	1865	175	1830	2234
	Spring	# Species	8	2	8	9
		Fraction	0.079	0.178	0.134	0.056
		N	1312	163	567	1368
	Summer	# Species	9	4	9	9
		Fraction	0.291	0.595	0.228	0.214
		N	3013	42	1389	1913
	Fall	# Species	7	4	7	9
		Fraction	0.071	0.5	0.091	0.099
		N	2575	184	1475	1541

Table B-29 Upper incipient lethal temperature (UILT) for EPT taxa from literature. Heat intolerant are those with UILT ≤ 30 in bold font.

Order	Family	Scientific Name	UILT*
Ephemeroptera	**Baetidae**	**Baetidae**	**26.1**
	Baetidae	Pseudocloeon sp.	41.1
	Caenidae	**Caenis sp.**	**26.7**
	Ephemeridae	Hexagenia bilineata	>30
	Ephemeridae	**Hexagenia limbata**	**26.6**
	Heptageniidae	**Heptagenia sp.**	**28.3**
	Heptageniidae	**Heptageniidae**	**22**
	Heptageniidae	**Stenonema femoratum**	**25.5**
Plecoptera	**Perlidae**	**Acroneuria sp.**	**30**
	Perlidae	**Perlidae**	**24.1**
	Taeniopterygidae	**Taeniopterygidae**	**29.5, 21**
	Taeniopterygidae	**Taeniopteryx sp.**	**29.5, 21**
Trichoptera	Hydropsychidae	Hydropsyche sp.	>35
	Hydroptilidae	**Hydroptila sp.**	**30-41.1**
	Hydroptilidae	**Hydroptilidae**	**30-41.1**
	Polycentropodidae	Neureclipsis sp.	>35

*Dallas and Ross-Gillespie 2015; Environmental Canada 2014; Nebeker and Lemke 1968; Stewart et al. 2013; Yoder and Rankin 2005

Table B-30 Number of organisms in EPT orders, number and fraction in heat-intolerant groups during benthic sampling at the LEC in 2017-2018 by gear, season, and zone.

Gear	Season	Statistic	Zone			
			Upstream Reference	Discharge	Thermally Exposed	Downstream
Hester-Dendy	Winter	Total EPT	184	318	376	198
		# Intolerant	31	23	33	38
		Fraction	0.168	0.072	0.088	0.192
	Spring	Total EPT	7856	5587	4768	7567
		# Intolerant	778	190	370	681
		Fraction	0.099	0.034	0.078	0.09
	Summer	Total EPT	2834	6067	5822	912
		# Intolerant	347	112	321	202
		Fraction	0.122	0.018	0.055	0.221
	Fall	Total EPT	952	1112	1374	858
		# Intolerant	97	63	151	101
		Fraction	0.102	0.057	0.11	0.118
Ponar	Winter	Total EPT	117	27	77	91
		# Intolerant	39	0	27	46
		Fraction	0.333	0	0.351	0.505
	Spring	Total EPT	103	29	76	76
		# Intolerant	23	0	10	17
		Fraction	0.223	0	0.132	0.224
	Summer	Total EPT	878	25	316	409
		# Intolerant	235	0	78	107
		Fraction	0.268	0	0.247	0.262
	Fall	Total EPT	183	92	134	152
		# Intolerant	106	3	83	66
		Fraction	0.579	0.033	0.619	0.434

Table B-31 Means and standard errors for individual metrics, and standardized differences for benthic invertebrates collected during winter sampling at the LEC in 2017-2018.

Season	Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
				Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Winter	Hester-Dendy	Composition	Fraction EPT	0.559	0.027	329	0.536	0.019	702	-0.692	0.489	0.025	405	-1.894
			EPT Species	14	1	329	14	1	702	0	16	1	405	1.414
		Density	Mean Countt	19.595	2.242	23	40.07	8.566	24	2.312	23.116	3.537	24	0.841
		Diversity	^0D	42	3.158	248	49	2.7	602	1.685	49	3.473	324	1.491
			^1D	17.32	1.54	248	17.41	0.88	602	0.052	25.945	1.593	324	3.893
			^2D	9.64	1.045	248	11.23	0.585	602	1.331	17.097	1.283	324	4.508
			^3D	7.288	0.894	248	9.506	0.499	602	2.166	13.633	1.155	324	4.344
		Thermal Tolerance	Fraction EPT Intolerant	0.168	0.028	184	0.088	0.015	376	-2.565	0.192	0.028	198	0.611
	Ponar	Composition	Fraction EPT	0.063	0.006	1865	0.042	0.005	1830	-2.867	0.041	0.004	2234	-3.135
			EPT Species	5	1	1865	4	1	1830	-0.707	7	1	2234	1.414
		Density	Mean Count	199.25	49.389	6	195.5	64.232	6	-0.046	238.68	84.919	6	0.401
		Diversity	^0D	42	3.13	556	36	2.911	330	-1.404	45	3.187	738	0.672
			^1D	10.136	0.631	556	9.249	0.821	330	-0.857	9.27	0.52	738	-1.058
			^2D	5.023	0.347	556	4.347	0.406	330	-1.265	4.861	0.228	738	-0.390
			^3D	3.81	0.26	556	3.309	0.289	330	-1.288	4.033	0.169	738	0.720
		Thermal Tolerance	Fraction EPT Intolerant	0.333	0.044	117	0.351	0.054	77	0.258	0.505	0.052	91	2.524

Table B-32 Means and standard errors for individual metrics, and standardized differences for benthic invertebrates collected during spring sampling at the LEC in 2017-2018.

Season	Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
				Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Spring	Hester-Dendy	Composition	Fraction EPT	0.778	0.004	10103	0.771	0.005	6186	-1.036	0.742	0.004	10200	-6.011
			EPT Species	27	1	10103	23	1	6186	-2.828	22	1	10200	-3.536
		Density	Mean Countt	601.73	90.27	23	605.3	128.19	14	0.023	776.26	122.51	18	1.147
		Diversity	^0D	48	1.552	6853	42	2.054	5275	-2.331	41	1.834	8523	-2.914
			^1D	8.099	0.121	6853	8.242	0.147	5275	0.751	8.32	0.092	8523	1.455
			^2D	5.015	0.088	6853	4.949	0.104	5275	-0.483	6.173	0.075	8523	10.031
			^3D	4.054	0.079	6853	3.905	0.086	5275	-1.275	5.382	0.083	8523	11.543
		Thermal Tolerance	Fraction EPT Intolerant	0.099	0.003	7856	0.078	0.004	4768	-4.084	0.09	0.003	7567	-1.911
	Ponar	Composition	Fraction EPT	0.079	0.007	1312	0.134	0.014	567	3.41	0.056	0.006	1368	-2.371
			EPT Species	8	1	1312	8	1	567	0	9	1	1368	0.707
		Density	Mean Count	140.17	39.812	6	60.58	17.486	6	-1.83	146.15	39.254	6	0.107
		Diversity	^0D	36	3.124	653	29	2.109	232	-1.857	40	2.544	763	0.993
			^1D	13.628	0.62	653	13.24	1	232	-0.328	15.518	0.604	763	2.183
			^2D	9.235	0.481	653	7.858	0.853	232	-1.407	10.984	0.462	763	2.624
			^3D	7.707	0.445	653	5.914	0.738	232	-2.081	9.361	0.463	763	2.576
		Thermal Tolerance	Fraction EPT Intolerant	0.223	0.041	103	0.132	0.039	76	-1.611	0.224	0.048	76	0.016

Table B-33 Means and standard errors for individual metrics, and standardized differences for benthic invertebrates collected during summer sampling at the LEC in 2017-2018.

Season	Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
				Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Summer	Hester-Dendy	Composition	Fraction EPT	0.309	0.005	9169	0.483	0.005	12049	26.23	0.231	0.007	3953	-9.443
			EPT Species	21	1	9169	22	1	12049	0.707	19	1	3953	-1.414
		Density	Mean Countt	546.1	195.54	23	687.7	271.02	24	0.424	246.14	40.486	22	-1.502
		Diversity	^0D	55	1.757	7900	56	2.784	11048	0.304	56	3.615	3085	0.249
			^1D	7.583	0.129	7900	6.915	0.089	11048	-4.258	7.814	0.23	3085	0.875
			^2D	3.93	0.066	7900	4.629	0.05	11048	8.443	3.595	0.106	3085	-2.681
			^3D	3.091	0.049	7900	4.068	0.044	11048	14.8	2.784	0.073	3085	-3.466
		Thermal Tolerance	Fraction EPT Intolerant	0.122	0.006	2834	0.055	0.003	5822	-9.802	0.221	0.014	912	6.577
	Ponar	Composition	Fraction EPT	0.291	0.008	3013	0.228	0.011	1389	-4.509	0.214	0.009	1913	-6.157
			EPT Species	9	1	3013	9	1	1389	0	9	1	1913	0.000
		Density	Mean Count	321.9	107.99	6	148.4	48.755	6	-1.464	204.38	46.634	6	-0.999
		Diversity	^0D	35	2.885	1513	27	1.76	705	-2.367	32	1.771	1318	-0.886
			^1D	8.66	0.272	1513	10.87	0.43	705	4.343	7.421	0.233	1318	-3.458
			^2D	5.361	0.188	1513	7.891	0.334	705	6.597	4.93	0.15	1318	-1.794
			^3D	4.396	0.168	1513	6.873	0.332	705	6.653	4.243	0.133	1318	-0.715
		Thermal Tolerance	Fraction EPT Intolerant	0.268	0.015	878	0.247	0.024	316	-0.737	0.262	0.022	409	-0.227

Table B-34 Means and standard errors for individual metrics, and standardized differences for benthic invertebrates collected during fall sampling at the LEC in 2017-2018.

Season	Gear	Type	Metric	Upstream Reference			Thermally Exposed				Downstream			
				Mean	Std Err	N	Mean	Std Err	N	Std Diff	Mean	Std Err	N	Std Diff
Fall	Hester-Dendy	Composition	Fraction EPT	0.966	0.006	986	0.931	0.007	1476	-3.993	0.913	0.009	940	-4.883
			EPT Species	17	1	986	19	1	1476	1.414	16	1	940	-0.707
		Density	Mean Countt	56.279	15.192	24	84.25	16.836	24	1.233	55.986	8.522	23	-0.017
		Diversity	^0D	33	3.427	788	39	2.693	1281	1.377	35	2.992	835	0.440
			^1D	4.926	0.247	788	6.065	0.236	1281	3.336	6.221	0.308	835	3.283
			^2D	3.288	0.109	788	3.906	0.109	1281	3.991	3.895	0.138	835	3.442
			^3D	2.968	0.095	788	3.492	0.091	1281	3.988	3.48	0.111	835	3.508
		Thermal Tolerance	Fraction EPT Intolerant	0.102	0.01	952	0.11	0.008	1374	0.618	0.118	0.011	858	1.085
	Ponar	Composition	Fraction EPT	0.071	0.005	2575	0.091	0.007	1475	2.213	0.099	0.008	1541	3.064
			EPT Species	7	1	2575	7	1	1475	0	9	1	1541	1.414
		Density	Mean Count	275.11	63.998	6	157.6	45.557	6	-1.496	164.64	39.814	6	-1.466
		Diversity	^0D	23	1.911	717	41	3.495	514	4.518	49	3.58	563	6.407
			^1D	5.613	0.27	717	10.39	0.601	514	7.257	11.03	0.75	563	6.795
			^2D	3.391	0.168	717	6.571	0.348	514	8.231	5.11	0.361	563	4.318
			^3D	2.814	0.143	717	5.625	0.303	514	8.385	3.841	0.262	563	3.444
		Thermal Tolerance	Fraction EPT Intolerant	0.579	0.036	183	0.619	0.042	134	0.719	0.434	0.04	152	-2.671

Table B-35 Sampling statistics for electrofishing sampling at LEC in 1980-1985, 1997-2002, and 2018-2018, by zone, habitat, and season. Only fish > 100 mm total length are included.

Zone	Habitat	Season	Survey	Number of Samples	Number of Fish	Biomass (Kg)	Mean N. Fish per 20 min	StdErr (Mean Mean N. Fish)	Mean Biomass (Kg per 20 min)	StdErr (Mean Biomass)
Upstream Reference	OLD	Winter	1980-1985	1	85	16.31	65.38		16.31	
			1997-2002	6	460	58.51	77.75	41.46	9.75	5.05
			2017-2018	6	95	109.23	15.48	5.74	18.21	7.73
		Spring	1980-1985	5	204	50.83	35.32	4.22	10.17	2.57
			1997-2002	6	229	271.6	33.02	6.72	45.27	9.77
			2017-2018	6	91	93.89	13.39	0.9	15.65	3.56
		Summer	1980-1985	6	188	70.72	23.74	6.21	11.79	5.58
			1997-2002	6	109	83.43	19.42	4.7	13.91	3.85
			2017-2018	6	64	50.48	9.27	2.41	8.41	3.24
		Fall	1980-1985	7	480	45.06	57.63	17.01	6.44	1.53
			1997-2002	5	120	97.38	28.1	10.29	19.48	8.65
			2017-2018	6	61	45.09	9.63	3.24	7.51	3.12
Discharge	DIS	Winter	1980-1985	1	36	14.13	32.73		14.13	
			1997-2002	6	454	430.49	76.32	10.06	71.75	13.21
			2017-2018	6	223	449.62	33.86	4.29	74.94	23.29
		Spring	1980-1985	5	277	112.97	55.45	15.69	22.59	5.15
			1997-2002	6	302	395.63	52.51	13.35	65.94	20.83
			2017-2018	6	129	235.88	19.43	3.67	39.31	12.46
		Summer	1980-1985	6	67	42.01	11.28	2.73	7	2.67
			1997-2002	6	113	133.11	18.83	5.34	22.19	4.81
			2017-2018	6	36	32	5.47	1.43	5.33	2.89
		Fall	1980-1985	7	456	176.4	64.3	29.52	25.2	10.63
			1997-2002	5	325	289.82	66.56	9.59	57.96	6.15
			2017-2018	6	127	418.39	19.47	4.67	69.73	20.58
Thermally Exposed	CXLD	Winter	1980-1985	1	25	8.35	20.83		8.35	
			1997-2002	6	90	90.75	15	4.2	15.12	2.02
			2017-2018	6	100	75.21	14.49	6.3	12.53	4.46
		Spring	1980-1985	5	237	52.65	47.4	15.09	10.53	1.92
			1997-2002	6	144	92.45	24	7.33	15.41	3.95
			2017-2018	6	82	95.18	12.09	1.7	15.86	3.82

Zone	Habitat	Season	Survey	Number of Samples	Number of Fish	Biomass (Kg)	Mean N. Fish per 20 min	StdErr (Mean Mean N. Fish)	Mean Biomass (Kg per 20 min)	StdErr (Mean Biomass)
Thermally Exposed	CXLD	Summer	1980-1985	6	136	61.68	22.67	7.64	10.28	4.94
			1997-2002	6	64	31.26	10.67	3.41	5.21	1.67
			2017-2018	6	54	56.14	8.01	1.8	9.36	3.14
		Fall	1980-1985	7	713	106.24	100.19	36.5	15.18	3.05
			1997-2002	5	48	73.09	9.6	3.23	14.62	2.37
			2017-2018	6	76	107.3	11.78	3.02	17.88	5.28
	OLD	Winter	1997-2002	6	106	136.96	17.54	3.32	22.83	6.95
			2017-2018	6	167	175.38	26.04	6.17	29.23	9.31
		Spring	1997-2002	6	136	163.26	22.52	7.24	27.21	4.47
			2017-2018	6	93	143.87	13.63	3.96	23.98	7.31
		Summer	1997-2002	6	114	117.25	20.24	5.45	19.54	4.59
			2017-2018	6	48	72.49	6.84	2.27	12.08	4.4
		Fall	1997-2002	5	123	180.42	24.04	3.87	36.08	6.87
			2017-2018	6	81	98.71	12.04	3.29	16.45	7.39

Table B-36 Diversity statistics of fish community in electrofishing sampling by zone and season during 1980-1985, 1997-2002, and 2017-2018 LEC studies based on numerical count and total biomass. Only fish > 100 mm total length are included.

Zone	Habitat	Season	Survey	Number of Fish	$^0D_{Count}$	$^0D_{Count}$ Standard Deviation	$^1D_{Count}$	$^1D_{Count}$ Standard Deviation	$^2D_{Count}$	$^2D_{Count}$ Standard Deviation	$^0D_{weight}$	$^1D_{weight}$	$^2D_{weight}$
Upstream Reference	OLD	Winter	1980-1985	57	9	1.32	3.33	0.49	2.11	0.27	9	4.63	3.76
			1997-2002	397	14	1.99	1.96	0.14	1.34	0.05	14	6.41	5.02
			2017-2018	29	17	2.16	9.06	1.25	6.22	0.92	17	7.43	5.57
		Spring	1980-1985	102	17	2.68	5.83	0.68	3.42	0.36	17	7.74	6.03
			1997-2002	83	19	1.04	8.95	0.73	5.52	0.6	19	8.33	5.39
			2017-2018	14	16	1.77	11.62	1.11	10.09	0.94	16	8.65	7.3
		Summer	1980-1985	47	18	2.16	9.37	0.74	7.34	0.59	18	7.66	6.25
			1997-2002	36	10	0.81	6.1	0.57	4.58	0.51	10	5.01	3.08
			2017-2018	14	14	1.22	10.13	1.07	8.09	1.1	14	8.97	7.08
		Fall	1980-1985	308	20	1.4	4.08	0.26	2.3	0.13	20	7.38	4.63
			1997-2002	46	13	1.48	6.37	0.65	4.39	0.47	13	4.97	3.26
			2017-2018	18	17	1.4	11.49	1.36	7.74	1.44	17	10.61	9.25
	DIS	Winter	1980-1985	9	10	1.38	7.9	1.16	6.75	1.1	10	6.7	5.73
			1997-2002	203	21	1.64	7.24	0.45	4.17	0.31	21	8.32	5.65
			2017-2018	55	22	3.1	9.56	0.91	6.78	0.52	22	5.31	2.98
		Spring	1980-1985	136	16	1.34	6.26	0.51	3.62	0.34	16	6.09	4.09
			1997-2002	130	15	1.49	6.99	0.48	4.38	0.39	15	4.19	2.3
			2017-2018	26	16	1.25	9.72	0.84	7.45	0.7	16	8.16	4.97
		Summer	1980-1985	10	12	1.05	10.07	0.8	9.18	0.82	12	6.33	4.17
			1997-2002	45	12	1.54	6.42	0.71	4.51	0.59	12	3.69	2.35
			2017-2018	10	10	0.98	7.95	0.95	6.61	1.04	10	6.43	5.61
		Fall	1980-1985	199	21	2.03	7.88	0.52	4.43	0.36	21	10.76	7.36
			1997-2002	160	21	2.25	7.23	0.63	3.72	0.34	21	9.94	7.03
			2017-2018	67	16	1.48	5.89	0.75	3.21	0.42	16	3.1	1.82

Zone	Habitat	Season	Survey	Number of Fish	$^0D_{Count}$	$^0D_{Count}$ Standard Deviation	$^1D_{Count}$	$^1D_{Count}$ Standard Deviation	$^2D_{Count}$	$^2D_{Count}$ Standard Deviation	$^0D_{weight}$	$^1D_{weight}$	$^2D_{weight}$
Thermally Exposed	CXLD	Winter	1980-1985	6	6	0.73	5.38	0.59	5.08	0.61	6	3.87	3.09
			1997-2002	23	14	1.93	8.75	1.02	6.82	0.85	14	8.28	5.6
			2017-2018	37	15	1.87	7.22	0.91	4.85	0.63	15	7.33	5.39
		Spring	1980-1985	162	20	2.7	4.2	0.51	2.09	0.17	20	7.9	5.67
			1997-2002	46	19	1.73	9.8	0.96	6.46	0.77	19	8.34	5.84
			2017-2018	10	18	1.73	13.9	1.33	12.05	1.27	18	10.23	8.31
		Summer	1980-1985	60	17	2.49	6.81	0.92	4.06	0.52	17	6.2	4.09
			1997-2002	21	10	0.88	6.66	0.78	5.01	0.73	10	6.64	4.78
			2017-2018	10	13	1.55	10.04	1.21	8.63	1.12	13	8.05	6.87
		Fall	1980-1985	504	25	2.04	3.75	0.24	1.96	0.09	25	8.71	5.94
			1997-2002	10	10	0.88	8.13	0.72	7.16	0.75	10	5.06	3.93
			2017-2018	18	15	1.47	10.42	1.16	8.11	1.13	15	7.05	5.84
	OLD	Winter	1997-2002	27	14	1.31	8.92	0.83	6.98	0.75	14	5.66	3.79
			2017-2018	58	19	2.45	8.42	0.91	5.51	0.61	19	8.43	7.07
		Spring	1997-2002	36	12	1.79	6.91	0.62	5.78	0.44	12	5.05	3.83
			2017-2018	23	17	1.98	10.92	1.26	8.26	1.16	17	10	8.07
		Summer	1997-2002	35	13	2.08	7.28	0.8	5.66	0.63	13	5.57	4.33
			2017-2018	11	11	0.97	8.74	0.84	7.38	0.9	11	8.29	7.14
		Fall	1997-2002	28	14	1.62	7.52	0.71	6.04	0.5	14	5.31	3.88
			2017-2018	15	17	1.67	11.51	1.27	9.1	1.14	17	8.83	7.09

Table B-37 Fish community in electrofishing sampling by zone, season, habitat, and type during 1980-1985, 1997-2002, and 2017-2018 LEC studies based on numerical count and total biomass. Only fish > 100 mm total length are included.

Zone	Habitat	Survey	Season	Number of Fish					Biomass (Kg)				
				Rough	Forage	Pan	Game	Special	Rough	Forage	Pan	Game	Special
Upstream Reference	OLD	1980-1985	Winter	77	5	1	2	0	15.04	0.752	0.39	0.132	0
			Spring	167	10	3	23	1	41.373	1.195	0.89	6.71	0.657
			Summer	140	15	2	31	0	55.957	0.934	0.162	13.667	0
			Fall	402	46	16	16	0	34.461	3.878	1.126	5.59	0
		1997-2002	Winter	444	13	2	1	0	55.475	2.531	0.142	0.365	0
			Spring	195	5	5	23	1	241.344	0.751	1.669	25.683	2.15
			Summer	97	0	5	7	0	72.026	0	2.647	8.757	0
			Fall	97	7	0	16	0	83.533	0.298	0	13.548	0
		2017-2018	Winter	69	8	1	17	0	80.797	0.289	0.48	27.665	0
			Spring	65	3	2	21	0	73.442	0.171	0.386	19.89	0
			Summer	48	6	0	9	1	43.082	0.409	0	6.009	0.98
			Fall	47	6	1	6	1	37.894	0.231	0.076	6.397	0.49
Discharge	DIS	1980-1985	Winter	14	17	2	3	0	9.852	0.755	0.456	3.064	0
			Spring	233	27	4	12	1	99.714	2.654	0.783	9.473	0.345
			Summer	42	4	0	21	0	30.323	0.668	0	11.021	0
			Fall	344	61	24	27	0	113.717	7.804	5.435	49.443	0
		1997-2002	Winter	365	37	16	36	0	216.668	5.461	6.509	201.853	0
			Spring	247	1	7	45	2	330.465	0.051	2.046	58.814	4.25
			Summer	99	1	0	13	0	127.116	0.088	0	5.908	0
			Fall	256	18	17	34	0	191.872	2.913	7.265	87.77	0
		2017-2018	Winter	135	6	1	80	1	167.3787	1.529	0.02	280.258	0.43
			Spring	94	0	1	33	1	101.602	0	0.068	119.946	14.262
			Summer	16	4	0	16	0	23.029	0.177	0	8.789	0
			Fall	49	1	0	77	0	81.004	0.02	0	337.364	0

Zone	Habitat	Survey	Season	Number of Fish					Biomass (Kg)				
				Rough	Forage	Pan	Game	Special	Rough	Forage	Pan	Game	Special
Thermally Exposed	CXLD	1980-1985	Winter	18	3	0	4	0	6.144	0.176	0	2.025	0
			Spring	205	9	10	13	0	43.14	0.565	1.316	7.633	0
			Summer	88	2	5	41	0	27.609	0.058	0.892	33.119	0
			Fall	643	17	31	21	1	79.832	1.971	3.941	17.892	2.6
		1997-2002	Winter	64	18	1	7	0	68.528	2.206	0.533	19.478	0
			Spring	115	4	4	21	0	78.678	0.728	1.229	11.811	0
			Summer	40	0	0	24	0	27.489	0	0	3.768	0
			Fall	36	6	1	5	0	64.276	2.074	0.069	6.675	0
		2017-2018	Winter	90	4	0	6	0	70.7296	0.465	0	4.0136	0
			Spring	64	0	2	15	1	84.489	0	0.278	9.875	0.54
			Summer	43	0	1	10	0	49.365	0	0.0233	6.7548	0
			Fall	56	5	0	14	1	84.003	0.167	0	22.383	0.75
	OLD	1997-2002	Winter	74	5	0	27	0	65.188	0.486	0	71.289	0
			Spring	88	0	1	47	0	77.158	0	0.225	85.88	0
			Summer	51	0	1	62	0	27.344	0	0.033	89.875	0
			Fall	75	1	3	44	0	91.525	0.162	0.585	88.147	0
		2017-2018	Winter	141	6	2	18	0	149.7344	0.722	0.489	24.435	0
			Spring	81	0	1	11	0	125.385	0	0.323	18.157	0
			Summer	36	2	0	10	0	52.354	0.044	0	20.092	0
			Fall	63	4	1	13	0	82.537	0.063	0.02	16.085	0

Table B-38 Heat tolerance of fish community in electrofishing sampling by zone, season, and habitat during 1980-1985, 1997-2002, and 2017-2018 LEC studies based on numerical count and total biomass. Only fish > 100 mm total length are included.

Zone	Habitat	Survey	Season	Number of Fish			Biomass (Kg)		
				Intolerant	Neutral	Tolerant	Intolerant	Neutral	Tolerant
Upstream Reference	OLD	1980-1985	Winter	6	7	72	1.142	3.48	11.692
			Spring	10	55	139	1.196	23.098	26.531
			Summer	15	42	131	1.713	16.737	52.27
			Fall	51	81	348	4.635	12.777	27.643
		1997-2002	Winter	12	23	425	2.451	13.694	42.368
			Spring	6	59	164	0.842	98.228	172.527
			Summer	0	46	63	0	57.728	25.702
			Fall	4	41	75	0.154	65.792	31.433
		2017-2018	Winter	11	51	33	2.007	82.993	24.231
			Spring	2	31	58	0.343	46.957	46.589
			Summer	5	18	41	0.198	26.179	24.103
			Fall	6	28	27	0.231	21.439	23.418
Discharge	DIS	1980-1985	Winter	8	18	10	0.584	8.906	4.637
			Spring	16	68	193	1.988	59.215	51.766
			Summer	4	26	37	0.668	28.691	12.653
			Fall	47	125	284	7.534	87.973	80.892
		1997-2002	Winter	36	96	322	5.363	251.609	173.519
			Spring	0	178	124	0	295.581	100.045
			Summer	1	61	51	0.088	96.177	36.847
			Fall	15	98	212	2.37	175.583	111.867
		2017-2018	Winter	6	110	107	1.5193	314.4014	133.695
			Spring	0	42	87	0	130.066	105.812
			Summer	4	8	24	0.177	12.718	19.1
			Fall	1	90	36	0.02	358.458	59.91

Zone	Habitat	Survey	Season	Number of Fish			Biomass (Kg)		
				Intolerant	Neutral	Tolerant	Intolerant	Neutral	Tolerant
Thermally Exposed	CXLD	1980-1985	Winter	7	5	13	2.201	0.897	5.247
			Spring	7	33	197	1.135	13.36	38.159
			Summer	3	41	92	0.34	38.238	23.1
			Fall	19	102	592	2.766	38.847	64.623
		1997-2002	Winter	18	39	33	2.206	61.219	27.32
			Spring	2	43	99	0.332	37.655	54.459
			Summer	0	6	58	0	6.745	24.512
			Fall	6	15	27	2.074	30.902	40.118
		2017-2018	Winter	5	32	63	0.5996	34.666	39.9426
			Spring	0	26	56	0	39.336	55.846
			Summer	0	16	38	0	26.8083	29.3348
			Fall	4	42	30	0.107	78.611	28.585
	OLD	1997-2002	Winter	5	49	52	0.486	103.704	32.773
			Spring	0	76	60	0	116.359	46.904
			Summer	1	52	61	0.18	59.835	57.237
			Fall	1	61	61	0.162	128.855	51.402
		2017-2018	Winter	6	38	123	0.722	64.4444	110.214
			Spring	1	27	65	0.323	62.43	81.112
			Summer	2	9	37	0.044	27.917	44.529
			Fall	4	26	51	0.063	60.145	38.497

Table B-39 Standardized differences of ecological metrics between survey 1 (1980-1985) and survey 3 (2017-2018) in Upstream Reference zone, OLD habitat.

Metric	Season	Mean value of metric in Survey 1	Standard Error of Metric	Number of Samples	Mean value of metric in Survey 3	Standard Error of Metric	Number of Samples	Difference of Metric Values	Pooled Standard Deviation	Standardized Difference
Abundance Count	Spring	35.32	4.22	5	13.39	0.90	6	-21.93	4.32	-5.08
	Summer	23.74	6.21	6	9.27	2.41	6	-14.47	6.66	-2.17
	Fall	57.63	17.01	7	9.63	3.24	6	-48.00	17.32	-2.77
Abundance (Kg)	Spring	10.17	2.57	5	15.65	3.56	6	5.48	4.39	1.25
	Summer	11.79	5.58	6	8.41	3.24	6	-3.38	6.45	-0.52
	Fall	6.44	1.53	7	7.51	3.12	6	1.07	3.48	0.31
Diversity ^0D	Winter	9	1.32	57	17.00	2.16	29	8.00	2.53	3.16
	Spring	17	2.68	102	16.00	1.77	14	-1.00	3.21	-0.31
	Summer	18	2.16	47	14.00	1.22	14	-4.00	2.48	-1.61
	Fall	20	1.40	308	17.00	1.40	18	-3.00	1.98	-1.52
Diversity ^1D	Winter	3.33	0.49	57	9.06	1.25	29	5.73	1.34	4.27
	Spring	5.83	0.68	102	11.62	1.11	14	5.79	1.30	4.45
	Summer	9.37	0.74	47	10.13	1.07	14	0.76	1.30	0.58
	Fall	4.08	0.26	308	11.49	1.36	18	7.41	1.39	5.35
Diversity ^2D	Winter	2.11	0.27	57	6.22	0.92	29	4.11	0.96	4.29
	Spring	3.42	0.36	102	10.09	0.94	14	6.67	1.01	6.63
	Summer	7.34	0.59	47	8.09	1.10	14	0.75	1.25	0.60
	Fall	2.30	0.13	308	7.74	1.44	18	5.44	1.45	3.76
Diversity ^3D	Winter	1.81	0.20	57	5.15	0.79	29	3.34	0.82	4.10
	Spring	2.77	0.27	102	9.38	0.94	14	6.61	0.98	6.76
	Summer	6.42	0.62	47	7.06	1.08	14	0.64	1.25	0.51
	Fall	1.94	0.09	308	5.90	1.32	18	3.96	1.32	2.99
	Winter	0.07	0.03	85	0.12	0.03	95	0.05	0.04	1.05

Metric	Season	Mean value of metric in Survey 1	Standard Error of Metric	Number of Samples	Mean value of metric in Survey 3	Standard Error of Metric	Number of Samples	Difference of Metric Values	Pooled Standard Deviation	Standardized Difference
Heat Intolerant Count	Spring	0.05	0.02	204	0.02	0.02	91	-0.03	0.02	-1.25
	Summer	0.08	0.02	188	0.08	0.03	64	0.00	0.04	-0.04
	Fall	0.11	0.01	480	0.10	0.04	61	-0.01	0.04	-0.19
Heat Intolerant (Kg)	Winter	0.07	0.03	85	0.02	0.01	95	-0.05	0.03	-1.67
	Spring	0.02	0.01	204	0.00	0.01	91	-0.02	0.02	-1.34
	Summer	0.02	0.01	188	0.00	0.01	64	-0.02	0.02	-1.21
	Fall	0.10	0.01	480	0.01	0.01	61	-0.10	0.02	-5.19
Heat Tolerant Count	Winter	0.85	0.04	85	0.35	0.05	95	0.50	0.06	7.99
	Spring	0.68	0.03	204	0.64	0.05	91	0.04	0.06	0.73
	Summer	0.70	0.03	188	0.64	0.06	64	0.06	0.07	0.82
	Fall	0.73	0.02	480	0.44	0.06	61	0.28	0.07	4.23
Heat Tolerant (Kg)	Winter	0.72	0.05	85	0.22	0.04	95	0.50	0.07	7.63
	Spring	0.52	0.04	204	0.50	0.05	91	0.03	0.06	0.41
	Summer	0.74	0.03	188	0.48	0.06	64	0.26	0.07	3.73
	Fall	0.61	0.02	480	0.52	0.06	61	0.09	0.07	1.39
Non-Rough Count	Winter	0.13	0.04	85	0.34	0.05	95	0.21	0.06	3.42
	Spring	0.19	0.03	204	0.37	0.05	91	0.19	0.06	3.25
	Summer	0.26	0.03	188	0.30	0.06	64	0.04	0.07	0.55
	Fall	0.17	0.02	480	0.33	0.06	61	0.16	0.06	2.58
Non-Rough (Kg)	Winter	0.13	0.04	85	0.39	0.05	95	0.26	0.06	4.16
	Spring	0.19	0.03	204	0.39	0.05	91	0.20	0.06	3.39
	Summer	0.22	0.03	188	0.20	0.05	64	-0.03	0.06	-0.50
	Fall	0.24	0.02	480	0.52	0.06	61	0.29	0.07	4.29

Table B-40 Standardized differences of ecological metrics between survey 1 (1980-1985) and survey 3 (2017-2018) in Thermally Exposed zone, CXLD habitat.

Metric	Season	Mean value of metric in Survey 1	Standard Error of Metric	Number of Samples	Mean value of metric in Survey 3	Standard Error of Metric	Number of Samples	Difference of Metric Values	Pooled Standard Deviation	Standardized Difference
Abundance Count	Spring	47.40	15.09	5	12.09	1.70	6	-35.31	15.19	-2.33
	Summer	22.67	7.64	6	8.01	1.80	6	-14.66	7.85	-1.87
	Fall	100.19	36.50	7	11.78	3.02	6	-88.41	36.63	-2.41
Abundance (Kg)	Spring	10.53	1.92	5	15.86	3.82	6	5.33	4.28	1.25
	Summer	10.28	4.94	6	9.36	3.14	6	-0.92	5.85	-0.16
	Fall	15.18	3.05	7	17.88	5.28	6	2.70	6.10	0.44
Diversity ^0D	Winter	6	0.73	6	15.00	1.87	37	9.00	2.01	4.48
	Spring	20	2.70	162	18.00	1.73	10	-2.00	3.21	-0.62
	Summer	17	2.49	60	13.00	1.55	10	-4.00	2.93	-1.36
	Fall	25	2.04	504	15.00	1.47	18	-10.00	2.51	-3.98
Diversity ^1D	Winter	5.38	0.59	6	7.22	0.91	37	1.84	1.09	1.70
	Spring	4.20	0.51	162	13.90	1.33	10	9.70	1.42	6.81
	Summer	6.81	0.92	60	10.04	1.21	10	3.23	1.52	2.13
	Fall	3.75	0.24	504	10.42	1.16	18	6.67	1.19	5.63
Diversity ^2D	Winter	5.08	0.61	6	4.85	0.63	37	-0.23	0.88	-0.26
	Spring	2.09	0.17	162	12.05	1.27	10	9.96	1.28	7.77
	Summer	4.06	0.52	60	8.63	1.12	10	4.57	1.24	3.70
	Fall	1.96	0.09	504	8.11	1.13	18	6.15	1.13	5.43
Diversity ^3D	Winter	4.91	0.62	6	4.03	0.54	37	-0.88	0.82	-1.07
	Spring	1.77	0.12	162	11.11	1.28	10	9.34	1.29	7.27
	Summer	3.27	0.40	60	7.90	1.09	10	4.63	1.16	3.99
	Fall	1.68	0.06	504	6.92	1.08	18	5.24	1.08	4.84
	Winter	0.28	0.09	25	0.05	0.02	100	-0.23	0.09	-2.49

Metric	Season	Mean value of metric in Survey 1	Standard Error of Metric	Number of Samples	Mean value of metric in Survey 3	Standard Error of Metric	Number of Samples	Difference of Metric Values	Pooled Standard Deviation	Standardized Difference
Heat Intolerant Count	Spring	0.03	0.01	237	0.00	0.01	82	-0.03	0.02	-1.90
	Summer	0.02	0.01	136	0.00	0.01	54	-0.02	0.02	-1.19
	Fall	0.03	0.01	713	0.05	0.03	76	0.03	0.03	0.99
Heat Intolerant (Kg)	Winter	0.26	0.09	25	0.01	0.01	100	-0.26	0.09	-2.88
	Spring	0.02	0.01	237	0.00	0.01	82	-0.02	0.01	-1.49
	Summer	0.01	0.01	136	0.00	0.01	54	-0.01	0.02	-0.34
	Fall	0.03	0.01	713	0.00	0.01	76	-0.03	0.01	-1.94
Heat Tolerant Count	Winter	0.52	0.10	25	0.63	0.05	100	-0.11	0.11	-0.99
	Spring	0.83	0.02	237	0.68	0.05	82	0.15	0.06	2.61
	Summer	0.68	0.04	136	0.70	0.06	54	-0.03	0.07	-0.37
	Fall	0.83	0.01	713	0.40	0.06	76	0.44	0.06	7.54
Heat Tolerant (Kg)	Winter	0.63	0.10	25	0.53	0.05	100	0.10	0.11	0.90
	Spring	0.73	0.03	237	0.59	0.05	82	0.14	0.06	2.24
	Summer	0.38	0.04	136	0.52	0.07	54	-0.15	0.08	-1.86
	Fall	0.61	0.02	713	0.27	0.05	76	0.34	0.05	6.34
Non-Rough Count	Winter	0.32	0.09	25	0.18	0.04	100	-0.14	0.10	-1.39
	Spring	0.16	0.02	237	0.34	0.05	82	0.19	0.06	3.23
	Summer	0.37	0.04	136	0.28	0.06	54	-0.09	0.07	-1.22
	Fall	0.11	0.01	713	0.34	0.05	76	0.24	0.06	4.23
Non-Rough (Kg)	Winter	0.29	0.09	25	0.36	0.05	100	0.07	0.10	0.68
	Spring	0.26	0.03	237	0.33	0.05	82	0.07	0.06	1.16
	Summer	0.58	0.04	136	0.34	0.07	54	-0.24	0.08	-3.05
	Fall	0.27	0.02	713	0.35	0.06	76	0.08	0.06	1.46

B.2 DERIVATION OF HEAT SENSITIVE FISH SPECIES

Heat tolerance data available in the literature from laboratory tests were used to categorize heat sensitive or intolerant species versus more heat tolerant species for several fish species that reside in the lower Missouri River. Although heat tolerance data are limited for some of these species (and nonexistent for several other species), the existing data were used to differentiate species less tolerant of the naturally high ambient temperatures in the river, according to the laboratory testing results. Temperatures greater than approximately 90-91°F (adjusted to 93-94°F as appearing in Table B-54) were used to differentiate heat tolerant fish species from more heat sensitive species.

The Table B-54 and Table B-55 present the tolerance limits for species of adult or juvenile fish commonly found in the vicinity of the LEC and the literature sources from which they originated. These data represent the temperatures at which acute mortality (typically for 50 percent of the test subjects when held for 24 or 48 hours) or active avoidance can occur. Test results were selected for the highest acclimation temperature available from the testing to best represent the actual ambient temperature to which the fish would be acclimated in the river.

The lab testing results are considered to be conservative in that the tests were conducted under controlled laboratory conditions, usually under temperature held constant for 24-48 hours or more, rather than under diel or spatial temperature fluctuations typically occurring in the river. Tests usually were conducted with fish specimens from locales other than the river, thus the test fish were not subjected to the lower Missouri River's thermal regime to which they could be adapted. Evidence is provided by collections of species from temperatures in the wild exceeding the supposed maximum temperature tolerated under lab conditions, such as documented in the Ohio River (EPRI 2013).

Table B-41 Upper temperature tolerance values (°F) at high acclimation temperature—adult & juvenile heat shock

Species	Value	Acclimation	Parameter	Comments	Source(s)
Pallid sturgeon	91.4, 95 92.1-95.9	82.4 75.2	CTM17%, CTM100% LTM(CTM)	Small sample size (6 fish) 20-203 mm fish	Chipps et al. 2010 Deslaurieres et al. 2016
Bighead carp	96.1	86.0	UILT50	103-134 mm fish	Sheng and Xu 2008
Silver carp	98.8	86.0	UILT50	103-134 mm fish	Sheng and Xu 2008
Gizzard shad	96.8 97.7	80.6-86 95.0	UILT50 24 h TL50	Ohio River Knoxville , TN	Yoder and Emery 2003 Hart 1952
Walleye	93.4 94.6 88.9	78.8-82.1 73.4 78.4	UUILT CTM UILT	Slow heating <1C/day Mean CTM for Iowa fish	Hokanson and Koenst 1986 Peterson 1993 Smith and Koenst 1975
Sauger	86.7	75.0	UILT50		Smith and Koenst 1975
Channel catfish	100.0 107.8	86.0 95	UILT CTM	Texas	Allen and Strawn 1967 Bennett, McCauley, and Beitinger 1998
Emerald shiner	100.1 95.4	77.0 66.2-77.0	CTM 7-day TL50 and UUILT	St. Louis Bay, L. Superior	Matthews and Maness 1979 McCormick and Kleiner 1976
White crappie	91.4 91.0	84.2 75.9	UILT >96 h TL50	Lake Erie	Brungs and Jones 1977 Reutter and Herdendorf 1976
Shorthead redhorse	95.2 91.9	69.1-74.8 69.1-74.8	CTM mean UUILT	Muskingham R. Ohio Muskingham R. Ohio	Reash 2000 et al. Reash 2000 et al.
River carpsucker	95.4 102.2	N/A 80.6-86.0	UILT UILT	Does not cite original source Ohio R.	Hasnian 2012 Yoder and Emery 2003
Freshwater drum	93.2 91.0	N/A 82.4-95.0	CTM UILT	Lake Erie Same UILT as Jinks 1981	Reutter and Herdendorf 1976 Houston 1982
Mooneye	90.7	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003
Goldeye	90.7	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003
Flathead catfish	100.0	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003
Longnose gar	100.9	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003
Shortnose gar	100.9	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003
Smallmouth buffalo	102.7	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003
Bigmouth buffalo	100.9	80.6-86.0	UILT	Ohio R.	Yoder and Emery 2003

Table B-42 Temperature tolerance values (°F) at high acclimation temperature—adult & juvenile avoidance

Species	Value	Acclimation	Parameter	Comments	Source(s)
Pallid sturgeon	N/A				
Bighead carp	94.1 91.4	86.0 77.0	Upper avoidance		Sheng and Xu 2008
Silver carp	96.8 91.6	86.0 77.0	Upper avoidance		Sheng and Xu 2008
Gizzard shad	93.2 93.0-93.9	80.6-86.0 N/A	Upper avoidance	Ohio R.	Yoder and Emery 2003 Churchill and Wojtalik 1969
Walleye	69.8 84.2	N/A 80.6-86.0	Upper avoidance	WI lake fish Ohio R.	Inskip and Magnuson 1983 Yoder and Emery 2003
Sauger	82.4	N/A	Upper avoidance		Coutant 1977
Channel catfish	95.0 93.2	86.0 80.6	Upper avoidance		Cherry et al. 1977
Emerald shiner	107.6 88.0	N/A 80.6-86.0	Upper avoidance Upper avoidance		Ellis 1984 Yoder and Emery 2003
White crappie	87.8 89.6	N/A	Upper avoidance Upper avoidance	thermal effluent IN	Proffit and Benda 1971 Yoder and Emery 2003
Shorthead redhorse	78.8 80.2	N/A	Upper avoidance Final preferendum	Should be <preference No original source cited	Coutant 1977 Hasnian 2012
River carpsucker	96.6	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Freshwater drum	86	N/A 80.6-86.0	Upper avoidance	Wabash River, IN	Coutant 1977 Yoder and Emery 2003
Mooneye	84.2	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Goldeye	84.2	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Flathead catfish	94.1	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Longnose gar	95.0	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Shortnose gar	95.0	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Smallmouth buffalo	96.8	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003
Bigmouth buffalo	95.0	80.6-86.0	Upper avoidance	Ohio River	Yoder and Emery 2003

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APPENDIX C
RIS PREDICTIVE EVALUATION METHODS

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C. PREDICTIVE EVALUATION DATA AND METHODS

This appendix discusses the types of biothermal data and their use in evaluating the potential for thermal impacts on the RIS. It also provides a reference list of literature sources from which biothermal data was obtained.

C.1 BIOTHERMAL RESPONSE MEASURES

Thorough review and evaluation of all reasonably available information from the literature provided biothermal data for the RIS. The biothermal data were used to quantify the following temperature responses of the RIS.

C.1.1. Survival of juveniles and adults

Aquatic organisms can adjust to the thermal environment physiologically, thereby shifting their tolerance range, but this acclimation has limits and ultimately a water temperature may be reached that would be lethal. The upper and lower lethal limits of thermal tolerance are defined as the temperature resulting in survival of 50 or 95_percent of the test organisms (TL50, TL95). The tolerance of organisms to extremes of temperature change is influenced by three factors: (1) their genetic ability to adapt to thermal changes within their characteristic temperature range; (2) the acclimation temperature prior to exposure to a change; and (3) the duration of exposure to the elevated temperature (Coutant 1972).

The upper incipient lethal temperature (UILT) can be defined as the highest temperature at which 50 percent (TL50) of a sample of organisms can survive long-term exposure (24 hours to one week) and is determined for each organism at the highest sustainable acclimation temperature. The lowest temperature at which 50 percent (TL50) of the warm acclimated organisms can survive long-term exposure is the lower incipient lethal temperature (LILT). UUILT is the ultimate upper temperature limit if gradual acclimation is allowed to continue (Fry et al. 1946).

C.1.2. Heat shock and cold shock

Immobilization or death resulting from sudden increases or decreases in water temperature beyond an organism's upper or lower tolerance limit is often referred to as "heat shock" or "cold shock", respectively. Short-term limits of tolerance to heat shock are estimated by TL95s or TL50s for exposures of seconds to a few hours. Tolerance to short-term (seconds to hours) exposures to temperature changes also depends on the acclimation temperature (Lauer et al. 1974; EA 1978; IA 1978; Greges and Schubel 1979). A sample of organisms acclimated to low temperatures typically can tolerate larger increases in temperature than a sample of the same organisms acclimated to temperatures near the high end of their range of tolerance (Lauer et al. 1974). "Cold-shock" relates to a sudden, sustained decrease in the temperature environment and is estimated by 24-hr or longer TL95s and TL50s.

C.1.3. Avoidance

In the case of mobile species, organisms may adjust to their thermal environment behaviorally by movement along existing temperature gradients. When exposed to a temperature gradient, unconfined, free-swimming juvenile and adult fish and other mobile organisms avoid stressful high temperature by moving through the gradient to water having lower temperatures (Meldrim et al. 1974; Neill and Magnuson 1974; TI 1976; EA 1978). Avoidance will typically occur as water temperature exceeds the species' preferred temperature by more than 3.6–9.0°F. Temperatures eliciting this avoidance response are called "avoidance temperatures" and are determined in the laboratory by observation of the positions of organisms maintained in a gradient of temperatures. Avoidance temperature is dependent on the temperature of prior acclimation; the temperature eliciting an avoidance response will generally increase as the acclimation temperatures increases, up to limits imposed by the UUILT.

C.1.4. Spawning and early development

The spawning temperature range is one measure of the suitability of the thermal environment for spawning and early development. The act of spawning may be relatively instantaneous for any individual and may coincide with a relatively narrow range of water temperatures. However, the conditioning that precedes the event and assures that mature individuals are at the appropriate stage of reproductive development when spawning temperatures occur can be a period of weeks or months (Hoar 1969; Hokanson 1977; Jones et al. 1976). Thus, reproductive condition in fish may represent a biological response to the range and average of environmental factors experienced during an extended period. Temperature is only one factor in a complex interrelationship of conditions conducive to spawning. These factors interact to assure that the time of spawning usually coincides with conditions (e.g., temperatures, food availability, salinity) conducive to development and survival of embryo and larval stages. The upper tolerance limits for hatching of eggs and for survival of larvae are also measures of the suitability of the thermal environment for spawning and early development of the RIS.

C.1.5. Optimum temperature for physiological performance

Within the range of thermal tolerance, there are temperature optima for metabolism controlling essential functions like growth and reproduction. Species are adapted to a range of temperatures in their environment over which they function at close to maximum physiological performance. As water temperatures increase above or below this range, physiological performance degrades.

The most sensitive indicator of the optimum temperature for performance is growth rate (Coutant 1972), and most of the thermal effects data on physiological functions reported in the literature are for growth. The optimum range for growth is defined as the range of temperature at which growth is not significantly different from the temperature supporting maximum growth. The maximum value in a species' temperature range for optimal growth typically coincides with the organism's final temperature preference (Brett 1971; Coutant 1975) and is often within 5.0-9.0°F of its maximum temperature tolerance for survival.

C.2 EVALUATION OF BIOTHERMAL RESPONSE

Sources of the biothermal response data used in the predictive RIS biothermal assessment are identified in the graphical analyses (thermal effect diagrams) presented in Section 6. The application of these data to the biothermal impact assessment is discussed below.

C.2.1. Thermal Shock Tolerance (Plume Entrainment)

The potential for mortality of planktonic organisms and life-stages during plume entrainment (heat shock) was predicted based on laboratory-determined TL50s for exposure durations ranging from 1 minute to 2 hours. Safe-temperature limits were calculated from TL50 data by subtracting 3.6°F. Although the 50 percent mortality endpoint is statistically the most precise measure of thermal tolerance, the use of safe-temperature estimates provides a higher level of protection for assessing the potential for acute effects. It has been shown for long term exposures (24 hours or more) that a 3.6°F safety factor is sufficient to adjust TL50 temperatures to temperatures at which essentially no mortality would occur (NAS/NAE 1973).

Safe-temperature limits were expressed as ΔT and compared graphically to ΔT exposures that could be experienced by a planktonic organism drifting through the LEC's thermal plume. The potential for mortality from excess temperature exposure was conservatively evaluated by comparing the safe-ΔT limits to the ΔTs experienced by an organism passing through the thermal plume. Sources of heat shock temperatures for the RIS are provided in Table B-1.

C.2.2. Mortality from Cold Shock

Thermal mortality can occur by cold shock, where aquatic organisms residing in elevated temperatures within the thermal plume are subject to temperatures below their thermal tolerance limits in the event of a plant shutdown. Cold shocks have the potential to cause mortality if the change in temperature exceeds the tolerance of the species.

The extent of the thermal impact due to cold shock depends on the magnitude and rate of the decrease in the discharge temperature as well as the actual discharge temperature at the time of the outage. The potential for cold shock was addressed using cold-shock data (24-hr to 96-hr TL50s or LILT) on each species as available. These lower temperature tolerance data were graphically compared to the maximum temperature drops that would occur in the event that the LEC was to suddenly shutdown. The thermal impact diagram used to make this comparison is explained in Section C.2.6. Sources of cold shock temperatures for the RIS are provided in Table C-1.

Table C-1 Literature Source and Assigned Codes for Thermal Response Data Used in the Biothermal Assessment

Reference Number	Citation
126	Allen, K.O. and K. Strawn, 1968. Heat tolerance of channel catfish, *Ictalurus punctatus*. Proceedings of the Annual Conference Southeastern Association of Game and Fish Commissioners 21(1967): 399–411.
173	Beitinger, T. L., W. A. Bennett, and R. W. McCauley. 2000. Temperature tolerances of North American freshwater fishes exposed to dynamic changes in temperature. Environmental Biology of Fishes, 58: 237-275.
161	Chipps, S.R., R.A. Klumb, and E.B. Wright. 2010. Development and application of juvenile pallid sturgeon bioenergetics model: Final Report, South Dakota State Wildlife Grant Program, Brookings, South Dakota, Study T–24–R Study No. 2424, 40 pp.
117	Clemens, H.P. and K. E. Sneed. 1957. The spawning behavior of the channel catfish *Ictalurus punctatus*. U. S. Fish Wildl. Serv. Spec. Sci. Rep.-Fish. No. 219, 11 pp
183	Cvancara, V. A., S. F. Stieber, and B. A. Cvancara. 1977. Summer temperature tolerance of selected species of Mississippi River acclimated young of the year fishes. Comp. Biochem. Physiol., 56A: 81-85.
160	Deslauriers, D., L.B. Heironimus, and S.R. Chipps. 2016. Test of a foraging-bioenergetics model to evaluate growth dynamics of endangered pallid sturgeon (Scaphirhynchus albus) Ecol. Mod. 336: 1-12.
1	EA Engineering, Science, and Technology (EA, formerly Ecological Analysts, Inc.). 1978. Hudson River Thermal Effects Studies for Representative Species--Final Report. Prepared for Central Hudson Gas and Electric Corporation, Consolidated Edison Company of New York, Inc., and Orange and Rockland Utilities, Inc. EA, Middletown, New York.

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177	Edwards, E.A., D.A. Krieger, G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: White crappie. U.S.D.I. Fish and Wildlife Service. FWS/OBS-82/10.7. 22 pp.
175	EPRI. 2011. Thermal Toxicity Literature Evaluation. EPRI, Palo Alto, CA: 2011. 1023095. 60 pp.
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191	Hokanson, K. E. F. 1990. A national compendium of freshwater fish and water temperature data Volume II: Temperature requirement data for thirty fishes. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Duluth, Minnesota. 331 pp.
163	Hupfeld, R. N., Q. E. Phelps, M. K. Flammang, and G. W. Whitledge. 2015. Short Communication: Assessment of the effects of high summer water temperatures on Shovelnose sturgeon and potential implications of climate change. River Res. Applic., 31:1195-1201.
176	McCormick, J.H., and C.F. Kleiner. 1976. Growth and survival of young-of-the-year emerald shiners (*Notropis atherinoides*) at different temperatures. Journal of the Fisheries Research Board of Canada 33:839–842.
162	Miller, I.R, K.M. Kappenmann, and M.J. Talbott. 2016. Upper lethal temperature of larval pallid sturgeon *Scaphirhynchus albus* (Forbes and Richardson, 1905). J. Appl. Ichthyol. 32:272-276.
170	Opuszynski, K., A. Lirski, L. Myszkowski, and J. Wolnicki. 1989. Upper lethal and rearing temperatures for juvenile common carp, *Cyprinus carpio* L., and silver carp, *Hypophthalmichthys molitrix* (Valenciennes). Aquac. Fish. Manag. 20:287–294.
171	Sheng, Lianxi and Jingbo Xu. 2008. Effects of Thermal Shock on Some Freshwater Fishes. 2nd International Conference on Bioinformatics and Biomedical Engineering, ICBBE 2008. 4535-4538. 10.1109/ICBBE.2008.293.
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172	Wismer, D.A. and A.E. Christie. 1987. Temperature Relationships of Great Lakes Fishes: A Data Compilation. Great Lakes Fish. Comm. Spec. Pub. 87-3. 165 pp.
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C.2.3. Upper Avoidance Temperatures

Avoidance temperatures were used to define areas of a thermal plume that potentially may be temporarily excluded as a zone of passage because of elevated temperatures. Avoidance temperatures were also used as a conservative estimate of the potential for the plume to exclude habitat from long-term occupation.

Avoidance temperatures are typically derived in a laboratory where observations are made on fish behavior in a thermal gradient. Most of the avoidance temperature data reported in the literature are measured during a relatively short exposure interval (e.g., 1-4 hours) and consequently are dependent upon acclimation temperature in the same manner as the UILT. Exclusion areas or restricted zones of passage based on these acute avoidance temperatures are best interpreted as temporary conditions since fish in a natural setting eventually would be able to acclimate to higher temperatures and thus be able to utilize portions of the "excluded" area. A more relevant avoidance parameter would be a chronic, or long-term upper avoidance temperature, but data on this parameter are rarely available. As a substitute for a chronic upper avoidance temperature, avoidance temperatures determined at high acclimation temperatures are often used. This chronic avoidance temperature generally would be expected to approach the UUILT for a species. Therefore, use of acute avoidance temperatures to evaluate the potential for habitat exclusion and blockage of fish movements is very protectively conservative.

The temperature elevation that elicits an avoidance response (i.e., avoidance temperature) depends on the temperature to which the organism is physiologically acclimated as it encounters a temperature gradient. Sources of upper avoidance temperatures for the RIS are provided in Table C-1.

Estimation of exclusion areas based on avoidance temperatures might suggest that the actual presence or absence of fish could be predicted. However, the actual presence or absence of organisms in a thermally altered area also is influenced by non-thermal factors, such as availability of food, cover, velocities, and substrate type. These non-thermal factors can override the temperature-avoidance response, thereby optimizing the overall survival of the organism (Brett 1971; Coutant 1970, 1975; Reynolds 1977, Spaulding 2014).

C.2.4. Optimum Temperatures for Growth

The optimum temperature and the upper end of the optimum temperature range for growth were used to evaluate the potential for the thermal plume to reduce growth of the RIS. These two measures of growth response to temperature are illustrated in the growth rate curve for striped bass post yolk-sac larvae and juveniles (EA 1978, Figure C-1). Maximum growth took place at 81.1 °F, while growth at 77.2 °F and 85.3 °F was not significantly less than at 81.1 °F. Thus, the range of temperatures for optimal growth is determined to be 77.2-85.3 °F, and the optimum temperature for growth in this example is the same as the upper end of the optimum range for growth, namely 85.3 °F. It is also apparent from the figure (Figure C-1) that growth continues at a high rate to a temperature of about 90 °F.

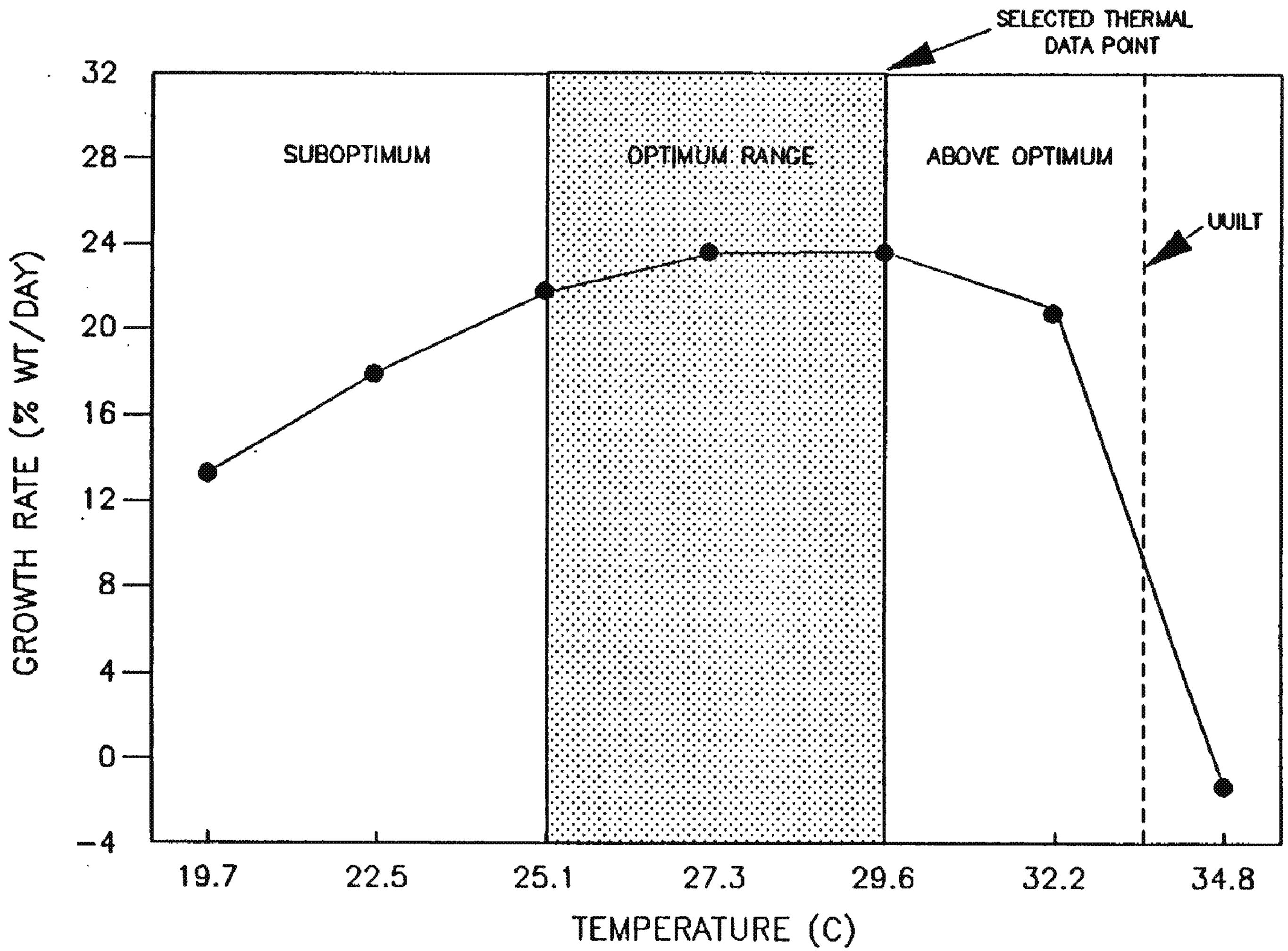


Figure C-1 Example of relationship among water temperature, growth, the optimum range for growth, and thermal tolerance (UUILT) for striped bass (adapted from EA 1978).

Thus, the upper limit of the temperature range optimal for growth was used whenever possible to estimate the maximum temperature permitting optimum or near-optimum growth. Extended exposure to temperatures above this limit (but below UUILT) do not necessarily contribute to thermal mortality or prohibit growth, but are higher than documented for optimal growth. Other factors being equal, plume temperatures above the upper limit of the optimum temperature range for growth would therefore reduce growth rate. Comparable estimates of this limiting growth temperature are the maximum weekly average temperatures (MWAT) for growth derived by Brungs and Jones (1977) (one-third of the range between a species' optimum growth temperature and its UUILT). The MWAT was used to define the maximum plume temperature allowing optimum growth and performance if the upper temperature limit of the optimal range for growth was not reported in the literature.

When plume temperatures are equal to, or less than, the optimum temperature for growth, they are more favorable for growth than are ambient temperatures. Other factors being equal, plume temperatures below the optimum temperature for growth would increase growth rate relative to ambient temperature. The optimum growth temperature was therefore used to estimate the maximum plume temperature resulting in enhancement of growth rates.

When data on optimum temperatures were not available, final thermal preferenda (preferred temperatures) were used as an estimate of the optimum temperature. The final preferendum is generally accepted as an estimator of the optimum temperature for growth (Brett 1971; Coutant 1975).

Growth response parameters are applicable for prolonged exposures (e.g., several days or weeks), and thus, is not relevant for estimating effects from short-term plume exposures. Furthermore, temperatures in excess of the upper limits of the optimum temperature range for growth would not necessarily exclude fish from an area, but merely indicate that growth and other physiological functions may not be functioning optimally. As noted by the NAS/NAE (1972), "optimum temperatures (such as those producing fastest growth rates) are not generally necessary at all times to maintain thriving populations and are often exceeded in nature during summer months." Although laboratory evidence indicates that fish tend to respond predictably to temperature, factors such as habitat type, food availability, and others can influence the thermal distribution of a fish species in the field (Reynolds 1977). Sources of optimal growth temperatures for the RIS are provided in Table C-1.

C.2.5. Spawning and Early Development

Temperature requirements for early development were used to define zones of the thermal plume that may have been suitable habitat for spawning and early development but may not be available for these activities because of the change in temperatures. The life stages addressed (when appropriate thermal effect data are available) are eggs, larvae, and early juveniles. The principal thermal response parameters are:

- successful spawning temperature range;
- upper end of the optimum temperature range for egg hatch; and
- thermal tolerance limits for larvae and early juveniles.

The upper limit of the optimum temperature range for hatch was used, whenever available, to identify areas of the thermal plume that may be unfavorable for egg incubation because of temperature. The maximum temperature for embryo survival also was used for this purpose when available. These thermal response parameters usually are determined from laboratory studies on hatching success. When this type of data was not available for a species, the upper limit of the temperature range for successful spawning was used to identify areas of the plume that may be unfavorable for spawning.

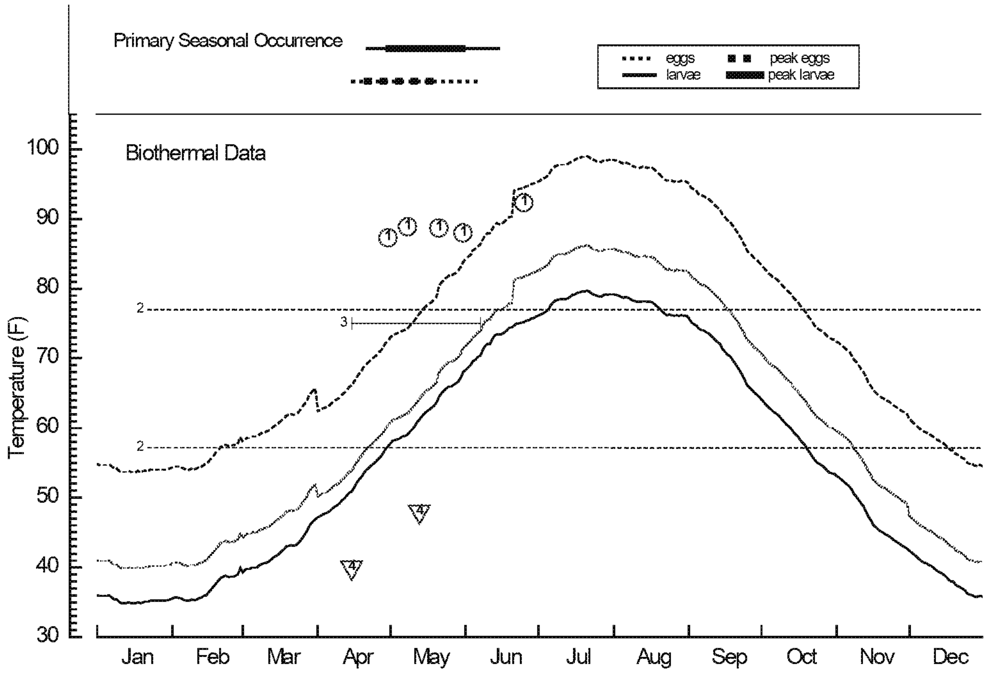
Tolerance limits, determined in the laboratory for larvae and early juveniles, were used to identify areas of the thermal plume that are potentially unsuitable as nursery areas. TL50s (24-hr to 96-hr), the UUILT and UILT were used.

Laboratory determined incipient-lethal temperatures are based on fairly rapid (sometimes instantaneous) temperature increases and are conditional on the acclimation state of the fish (i.e., the temperature at which the fish's physiological and biochemical functions are equilibrated). If given the opportunity to acclimate slowly to higher temperatures (a condition that usually exists in the natural setting), young fish would be able to utilize warmer zones within the thermal plume than would be predicted on the basis of incipient-lethal temperatures alone. The ultimate incipient-lethal temperature is not constrained by acclimation temperature, and, although rarely available for early life stages, is therefore a better indicator of the long-term thermal suitability of the plume as nursery habitat. Sources of optimal temperatures for spawning and development for the RIS are provided in Table C-1.

C.2.6. Thermal Effects Diagrams and Effects Frequency Diagrams

Thermal effect diagrams were used to compare biothermal response data for cold-shock and spawning/early development to plume temperatures at the edge of the zone of initial mixing throughout the year. A hypothetical example and explanation of the basic elements of a thermal effect diagram is shown in Figure C-2 Thermal effect diagrams were constructed for each of the RIS by plotting biothermal response data in relation to the prevailing acclimation temperature of the organisms (i.e., ambient temperatures in the case spawning/early development and plume temperatures in the case of cold shock). However, for predicted effects to be meaningful, they must be considered in light of the occurrence and distribution of each selected species or life stage within the vicinity of the plume. For example, if a life stage is not in the vicinity of the LEC when plume temperatures exceed its thermal requirements, then in reality no effect is possible.

The thermal effect diagrams were used primarily to identify the likelihood of cold-shock or reduced reproductive success for each of the RIS, as well as the periods of time when the potential effect might occur. The temperature profile, thermal response, and seasonal occurrence elements included in the thermal effect diagrams are illustrated in the hypothetical example shown in Figure C-2.



The thermal impact diagram was used to graphically examine the potential for cold-shock and effects on reproduction.

Hydrothermal Parameters

The temperature profile consists of curves for ambient temperature and approximate maximum temperature in the discharge channel (for cold-shock) or at the edge of the zone of initial dilution (ZID)(for spawning/early development). The ambient temperature curve was based on the 5-day mean ambient temperatures at the LEC. Since the maximum temperatures at the ZID occupy a relatively small area of potential habitat for aquatic organisms, this temperature is shown to provide perspective on the relative potential for more spatially extensive effects.

Biothermal Effect Parameters

Biothermal effects data were plotted above (spawning/early development) or below (cold-shock) the appropriate acclimation temperature for the period of time when the applicable life stage occurs in the vicinity of the LEC. The line marked "2" represents the spawning temperature range for the species and identifies the normal temperature conditions for peak spawning. The line marked "3" represents the maximum temperature compatible with optimum hatching success of eggs and is plotted as a line spanning the seasonal occurrence of eggs. The points marked "1" represent upper tolerance limits estimated by 24-hr to 96-hr TL50s. They are plotted directly above the point on the ambient temperature profile equivalent to the acclimation temperature at which the TL50 was determined. When the acclimation temperature exceeds the high ambient temperature, the TL50 is plotted directly above the highest ambient temperature. The points marked "4" indicate lower tolerance limits and are plotted directly below the point on the discharge channel or plume temperature equivalent to the acclimation temperature at which the lower tolerance limit (LILT) was determined. In the example, all lower tolerance limits lie below the ambient temperature; thus, there is no potential for cold shock mortality to organisms acclimated to the thermal plume if they were returned rapidly to ambient conditions during a plant shutdown.

Primary Seasonal Distribution

Above each biothermal effect diagram, the period of occurrence for applicable life stages was plotted as a series of bars. The bars indicate the primary season of occurrence based on life history information and densities measured in the field and impingement and entrainment sampling conducted during 1976, 2003 and 2007.

Figure C-2 Hypothetical example of the biothermal effect diagrams with explanation.

Table C-2 Maximum Temperatures at which RIS caught in three regions of the Ohio River (EPRI 2013).

Species	Lower River		Middle River		Upper River	
	°F	N	°F	N	°F	N
Bighead carp	88.7	12	81.1*	2	-	0
Channel catfish	96.8	494	113.5	1,332	101.1	1,586
Emerald shiner	96.8	473	108.0	1,434	101.1	1,738
Gizzard shad	96.8	550	115.3	1,556	101.1	1,918
Sauger	95.9	482	115.3	1,515	99.3	1,888
Silver carp	89.6	49	84.9	11	-	0
Walleye	89.4	12	89.2	85	88.2	442
White crappie	91.4	72	88.7	101	88.2	82

N = total sample size

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